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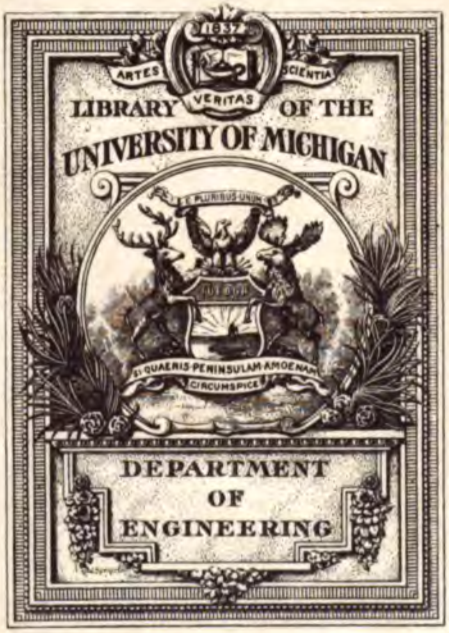

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JOURNAL OF THE UNITED STATES ARTILLERY

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VOLUME 47
1917

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1917

CONTENTS BY NUMBERS

No. 1

BRITISH "TANK" IN ACTION ON THE SOMME FRONT ---- (*Frontispiece*)
SEARCHLIGHTS ---- 1
By First Lieutenants Clair W. Baird and Edward P. Noyes, C. A. C., U. S. Army.
THE USE OF KEROSENE AND ALCOHOL IN THE GASOLINE ENGINES INSTALLED IN THE FORTIFICATIONS OF THE UNITED STATES ---- 24
By Captain Charles O. Schudt and First Lieutenant John W. Wallis, C. A. C., U. S. Army.
THE SUPPLY OF AN ARMY ---- 36
By Captain Jairus A. Moore, C. A. C., U. S. Army.
A SET-FORWARD RULER ---- 46
By Captain Clifford Jones, C. A. C., U. S. Army.
A TIME-RANGE BOARD ---- 48
By First Lieutenant Oscar Krupp, C. A. C., U. S. Army.
NOTES ON THE TIME-RANGE BOARD DESIGNED BY LIEUT. KRUPP, C. A. C. ---- 52
By Colonel William G. Haan, Captain James P. Robinson, and First Lieutenant Robert D. Brown, C. A. C., U. S. Army.
TIME-RANGE BOARD FOR GUNS ---- 55
By Captain George A. Wildrick, C. A. C., U. S. Army.
USE OF HEAVY ARTILLERY ON RAILWAY CARS AND AUTO TRUCKS IN THE EUROPEAN WAR ---- 68
By Captain Frank T. Hines, C. A. C., U. S. Army.
AN AUTOMOBILE TARGET FOR LAND DEFENSE GUNS ---- 83
By Captain Le Roy Bartlett, C. A. C., U. S. Army.

PROFESSIONAL NOTES:

Naval Stations and Naval Bases ---- 85
Military and Technical Considerations of Battleship Design ---- 92
Our Superb Battle-Cruisers ---- 101
The "Colorado" Class of Battleships ---- 104
The Privately Owned Naval Scout ---- 107
The Captured German Mine-Laying Submarine ---- 109
Slide-Rule for Finding Range to Clear Crest ---- 111
Wind Dial Corrector ---- 112
An Aeroplane Machine Gun that Fires Between the Revolving Propeller Blades ---- 114
Armored Automobiles—A War Machine that has Undergone Many Changes ---- 117

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CONTENTS BY NUMBERS

SHORT NOTE.......... 120

[illegible] of Gun Fire—Anti-Aircraft Guns for U. S. Navy.

NOTICES.......... 121

BOOK REVIEWS:.......... 122

[illegible]—Military and Naval America—Technique of Modern Tactics—Problems in Troop Leading—Awake! U. S. A. —How to Make Low Pressure Transformers.

No. 2

A GERMAN SUBMARINE OF MODERN TYPE.......... *Frontispiece*

THE POSSIBILITIES OF RAILROAD COAST ARTILLERY.......... 129
By First Lieutenant Meade Wildrick, C. A. C., U. S. Army

A SYSTEM OF MOBILE COAST ARTILLERY DEFENSE.......... 1[illegible]6

ANTI-AIRCRAFT DEFENSES FOR COAST FORTIFICATIONS 166
By Major Thomas Q. Ashburn, C. A. C., U. S. Army

THE SCIENTIFIC AND ANALYTICAL STUDY OF MILITARY HISTORY.......... 174
By Captain Howard L. Landers, C. A. C., U. S. Army

OBSERVATION OF FIRE.......... 199
By First Lieutenant Cecil G. Young, C. A. C., U. S. Army

CROSS-SECTION PAPER TIME-RANGE CHARTS FOR USE IN PLOTTING ROOM OR AT GUNS.......... 213
By Captain Hugh B. McElgin, C. A. C., U. S. Army

AN AUTOMOBILE TARGET AND A DEVICE FOR REMOVING A DUMMY PROJECTILE STUCK IN A MORTAR.......... 216
By First Lieutenant Leigh F. J. Zerbee, (C. A. C.) S. C., U. S. Army

A BATTERY COMMANDER'S STATION.......... 218
By Captain Jacob Frank, C. A. C., U. S. Army

A CIRCULAR LOGARITHMIC PREDICTER.......... 222
By Second Lieutenant C. M. Frost, C. A. C., Cal. N. G.

PROFESSIONAL NOTES:
- Aerial Navigation Over Water.......... 225
- The Development of Our Fleet and Naval Stations.......... 237
- Design of Submarines—Suitability of Current Design of Submarines to the Needs of the United States Navy.......... 250
- The Testing of Automobile Motors—Methods Followed and Apparatus Required 256
- Machine-Gun Range Tables for Flying Targets.......... 263
- The U. S. Submarine *L-1* (illustration).......... 265
- Naval Notes 266

NOTICES:.......... 267

BOOK REVIEWS:.......... 268

Coast Artillery Matériel—Lessons in Visual Signaling—The South American Wars of Independence—The Swiss Army System.

CONTENTS BY NUMBERS

No. 3

A FRENCH RAIL-ROAD GUN (*Frontispiece*)

INITIAL STRATEGY ON OUR NORTH ATLANTIC FRONTIER—A STUDY IN THE PREPARATION OF WAR PLANS TO MEET CERTAIN CONDITIONS 271
By Captain HOWARD L. LANDERS, C. A. C., U. S. Army

ANTI-AIRCRAFT WEAPONS 297
By Major ELMER J. WALLACE, C. A. C., U. S. Army

MILITARY AND NAVAL CO-OPERATION 330
By Brigadier-General JOHN W. RUCKMAN, U. S. Army

THE RESERVE OFFICERS' TRAINING CORPS IN THE LAND GRANT COLLEGES 354
By Captain ROBERT R. WELSHIMER, C. A. C., U. S. Army

PROFESSIONAL NOTES:
- Erosion of Guns—The Hardening of the Surface 392
- The Military Value of Coal and Iron 406
- Test of Radio Telephone of Aeroplanes 410

BOOK REVIEWS: 411
A Primer for the Officers' Reserve Corps and Officers of the Volunteers and National Guard—Notes on Military Explosives—Spanish for Soldiers.

INDEX TO VOLUME 47

JANUARY-JUNE, 1917

I. Authors

Ashburn, T. Q. Anti-Aircraft Defenses for Coast Fortifications 166
Baird, C. W. Searchlights 1
Bartlett, Le R. An Automobile Target for Land Defense Guns 83
Blethen, C. B. Awake! U. S. A. (Review) 127
Brown, R. D. Notes on the Time-Range Board Designed by Lieut. Krupp 52
Cathcart, W. L. The Development of our Fleet and Naval Stations (Reprint) 237
Clark, F. S. Military and Naval America (Review) 122
Cox, R. F. How to Make Low-Pressure Transformers (Review) 128
Fay, H. Erosion of Guns—The Hardening of the Surface (Reprint) 392
Frank, J. A Battery Commander's Station 218
Frost, C. M. A Circular Logarithmic Predictor 222
Frost, C. M. The Swiss Army System (Review) 270
Gatewood, R. D. Military and Technical Considerations of Battleship Design (Reprint) 92
Gilmore, J. C. Problems in Troop Leading (Review) 126
Hann, W. G. Notes on the Time-Range Board Designed by Lieut. Krupp, C. A. C. 52
Hines, F. T. Use of Heavy Artillery on Railway Cars and Auto Trucks in the European War 68
Jehle, F. The Testing of Automobile Motors—Methods Followed and Apparatus Required (Reprint) 256
Jones, C. A Set-Forward Ruler 46
Kennedy, J. N. Slide-Rule for Finding Range to Clear Crest (Reprint) 111
Kennedy, J. N. Wind Dial Corrector (Reprint) 112
Krupp, O. A Time-Range Board 48
Landers, H. L. Gallipoli (Review) 122
Landers, H. L. Initial Strategy on Our North Atlantic Frontier—A Study in the Preparation of War Plans to Meet Certain Conditions 271
Landers, H. L. The Scientific and Analytical Study of Military History 174
Landers, H. L. The South American Wars of Independence (Review) 269
McElgin, H. B. Cross-Section Paper Time-Range Charts for Use in Plotting Room or at Guns 213
Moore, J. A. The Supply of an Army 36

INDEX

get, and a device for removing a dummy projectile
n a mortar 216
defense guns 83
ation, and a French rail-road gun (il.) 271
ander's station 218
s, our superb 101
sign, military and technical considerations of 92
Colorado class, the first of our battleships to mount the
nch gun 104
ado class, illustration of 105
k" in action on the Somme front (il.) 1
on, the military value of 406
lery, railroad, possibilities of 129
bile, defense 156
lass of battleships 104
tion paper time-range charts for use in plotting room or at
guns 213
of guns—the hardening of the surface 392
evelopment of, and naval stations 237
targets, machine-gun range-table for 263
rail-road gun and an observation balloon (il.) 271
ne engines, use of kerosene and alcohol in 24
n mine-laying submarine (il.) 110
submarines from a British viewpoint 266
submarine of modern type (il.) 129
s, erosion of 392
vy artillery, use of on railway cars and auto trucks in the European war 68
story, military, scientific and analytical study of 174
itial strategy on our North Atlantic frontier—a study in the preparation of war plans to meet certain conditions 271
Kerosene and alcohol, use of in the gasoline engines installed in the fortifications of the U. S. 24
Machine-gun range-table for flying targets 263
Military and naval co-operation 330
Military and technical considerations of battleship design 92
Military history, the scientific and analytical study of 174
Mine-laying submarine, German 109
Naval scout, privately owned 107
Naval stations, development of our fleet and 237
and naval bases 85
Observation of fire 199
Official records of the union and confederate armies, compilation and printing of 195
Predicter, circular logarithmic 222
Prize essay, 1916, first prize 129
1916, second prize 271
Radio-telephone of aeroplanes, test of 410
Railroad coast artillery, possibilities of 129
Range-table, machine-gun, for flying targets 263
Reserve officers' training corps in the land grant colleges 354
Searchlights 1

Set-forward ruler 46
Shell fire, effect of on warships 120
Slide-rule for finding range to clear crest 111
Strategy on our North Atlantic frontier 271
Submarine, captured German mine-laying 110
    German, of modern type (il.) 129
    German, from a British viewpoint 266
    design of 250
    U. S. *L-1* (il.) 265
Targets, flying, machine-gun range-table for 263
Time-range board 48
    notes on the time-range board designed by Lieut. Krupp 52
    for guns 55
U. S. submarine *L-1* (il.) 265
Warships, effect of shell fire on 120
Wind dial corrector 112

III. Book Reviews

Awake! U. S. A. 127
Coast Artillery Matériel 268
Gallipoli 122
How to Make Low-Pressure Transformers 128
Lessons in Visual Signaling 269
Military and Naval America 122
Notes on Military Explosives 411
Primer for the Officers' Reserve Corps and Officers of the Volunteers and National Guard, U. S. Army 411
Problems in Troop Leading (An Infantry Division) 126
South American Wars of Independence 269
Spanish for Soldiers 412
Swiss Army System 270
Technique of Modern Tactics. A Study of Troop Leading Methods in the Operations of Detachments of All Arms 126

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JOURNAL UNITED STATES ARTILLERY

PRIZE ESSAY COMPETITION

1917

JOURNAL U. S. ARTILLERY

January-February, 1917

ERRATA

Page 8. 2nd paragraph, 3rd line: Transpose *comma* after carbon with *s* in temperature.

" 8. 4th paragraph, 3rd line: Precede the first word (crater) by *the*.

" 16. 2nd paragraph, 5th line: Transpose *the* at end of line to end of following line.

" 41. Under MAIN OR BASE DEPOTS, 2: *mamunition* should be *ammunition*.

" 48. Under DESCRIPTION, 1st paragraph, 5th line: Place a hyphen between *cross* and *section*.

" 62. Table: Heading (Set-forward Ranges Determined by Systems) refers only to *1909*, *1914*, and *Proposed*.

" 83. Under ADVANTAGES, 1st line: *in* should be *on*.

" 93 Foot-note, next to last line: *Nava* should be *Naval*.

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PRIZE ESSAY COMPETITION

1917

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(c) All essays entered in competition will become the property of the Journal of the United States Artillery. These will be published, if approved by the Coast Artillery School Board.

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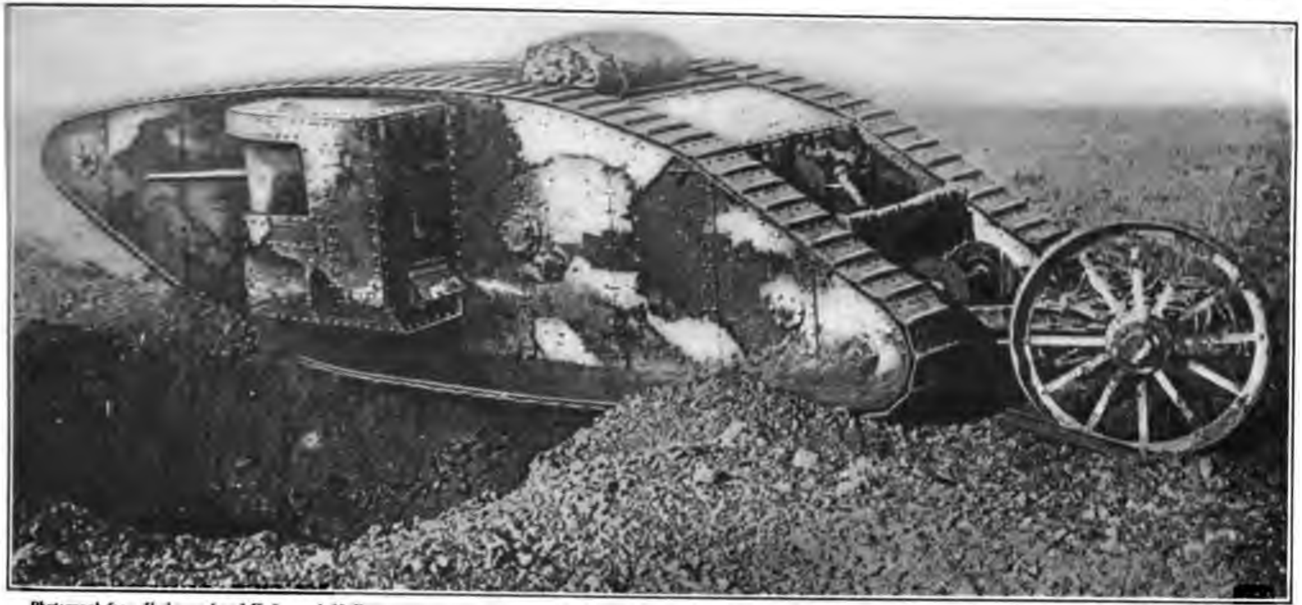

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BRITISH "TANK" IN ACTION ON THE SOMME FRONT
(SEE REPRINT FROM "SCIENTIFIC AMERICAN SUPPLEMENT" ON PAGE 117.)

JOURNAL
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UNITED STATES ARTILLERY

VOL. 47, No. 1 JANUARY-FEBRUARY, 1917 WHOLE No. 143

SEARCHLIGHTS[1]

By FIRST LIEUTENANTS CLAIR W. BAIRD AND EDWARD P. NOYES
COAST ARTILLERY CORPS, U. S. ARMY

HISTORY

Searchlights were first used in the Civil War. These were fitted with metal mirrors and were very crude. The first electrical searchlight was employed in the year 1867 by the French but it proved to be of little practical value until the invention of the Mangin mirror in the year 1877.

In the course of the war of 1870-1871, several projectors were used at Paris, but without any great success. The electric dynamo, however, gave considerable impetus to their employment, and the construction of illuminating apparatus was therefore begun; but, because of its slight mobility, it could be used only during siege operations and then only on the defensive side. Fortified places were but scantily provided with projectors, and since it was in the first stages of development there was but one size of mirror, i.e., thirty-five inch; it was hoped that with that size all the situations arising during the siege could be properly faced. No one occupied himself with the tactical use of projectors, and the night exercises where they played their proper part were rare. The sites chosen for the apparatus were often just the reverse of what they should have been and but little thought was given, indeed none at all, to the use of lights according to the tactical situation. The troops were not sufficiently interested in these new engines of war and, also, they could not believe that there was any well advised use for them.

---

[1] Extracts from a thesis prepared at the Coast Artillery School.

Things changed somewhat after the introduction of rapid fire arms. Night operations then began to take on a greater importance and, following that, a more serious view was taken of the question of searchlight projectors.

During the Spanish-American War several of our coast defenses were supplied with searchlights and the Spaniards also used searchlights to a certain extent in the defense of Santiago Bay. This war was too brief however to show their importance.

The Russo-Japanese War and especially the siege of Port Arthur in 1904-1905, very greatly modified the idea which had been held until that time on the subject of siege operations. Fighting at short distances again played an important part, as it had done in the 17th and 18th centuries. The implements used in fighting, large and small, which had been considered as obsolete, returned to the stage, although modern science modified them somewhat. The illumination of the immediate surrounding territory assumed considerable importance and that not only in siege operations but also in the field, and the employment of searchlights for sweeping the country in field operations dates from the campaign in Manchuria. By that time the designers had practically perfected the projector itself, but equal progress had been made in considering its proper employment and there still remained much to be done in this respect. (From *International Review* of 1912.)

In the siege of Port Arthur there were twelve searchlight installations: six on the land front, supplying two lights of 29.5-inch and four of 35-inch; and six on the sea front, two of 16-inch and four of 35-inch. Experience showed that the maximum range of these lights over sea was as follows:

35-inch..........	About 3¾ miles.
29.5-inch (naval)..	No figures, as they were used on land.
16-inch (naval)....	About 2 miles.

Although these lights, especially those on the sea front, proved to be very valuable, poor power-plants which were constantly breaking down, lack of uniform control, lack of any fixed system, lack of communication between the different lights, and poor tactical use, greatly reduced their importance.

In the present great European War reports are still too ger to obtain any accurate information in regard to the of searchlights at the front and at coast fortifications, but known that many of the large cities are equipped with them as a defense against raids from air-craft, and that they have proven of great value.

Until the last year or so the progress in the development of the searchlight had remained at a stand-still for about twenty-five years. At the present time there is some interest being displayed in their development in this country as manifested by the Beck and Sperry lights which are being placed on the market. While the principles upon which these lights operate have been known for years, it appears that no practical application of them has heretofore been attempted.

DEVELOPMENT

Although the lights for some projectors have been produced by chemical action, such as acetylene, etc., these have proved inferior in power to the electric light, and as practically all types of modern searchlights use the electric arc as their source of illumination, it is perhaps well to start with a brief discussion of the arc and the ordinary arc lamp.

In 1800 Volta discovered his pile and toward the end of the same year Sir Humphrey Davy made a medium of electric communication between two pieces of charcoal connected to Volta's pile, and discovered that an evident combustion was produced, the carbon remaining red hot for some time after contact was broken, the carbons throwing off white coruscations. This might be said to be the first discovery of the arc although it did not assume any practical importance until the invention of the electric dynamo in the latter part of the nineteenth century.

When an electric current is made to flow across a small gap from the tip of one carbon to another, an electric arc is formed. The carbon points are heated to a brilliant incandescence, gradually vaporized and burned up by oxygen in the air. The electric current passes from one tip to the other in this stream of incandescent vapor. If the rods are composed of pure carbon, by far the greater part of the light is emitted by the glowing tips of the rods, and but little by the carbon vapor. With direct current, the positive carbon or anode forms a crater and the negative or cathode burns to a point. This crater in the positive gives off most of the light, its greatest intensity being at from 30 to 45 degrees from the longer axis of the carbon, depending upon the size of the negative, length of arc, material of rod, and shape of crater. This quality makes the direct current especially adapted to searchlights, since most of the light can be directed against the reflector. Since the arc is very unstable and can be started only by bringing the carbons in contact with each other, means must be provided for starting it, for maintaining it at the proper length, for maintaining the desired current and voltage, for feeding the carbons together as they are vaporized, and for keeping it in focus. The stability of the arc is greatly improved by the use of a ballasted resistance in series with it. The necessity of this can be seen from the following: If the arc be burning steadily across a constant potential source and the voltage be decreased slightly, the current would also decrease slightly and would nor vaporize the carbons so rapidly. The stream of conducting vapor would then be decreased in size or in intensity, which would still further decrease the current and so on until the arc was extinguished. On the other hand, if the voltage increased slightly the current would continue to increase until a short circuit was virtually made. With a ballasting resistance the voltage across the mains is taken up both in the *IR* drop of the resistance and the arc. If the voltage across the mains becomes a little greater and causes a greater current to flow through the lamp, the *IR* drop across the resistance becomes enough greater to cause a slight decrease in the voltage across the arc, and vice versa. Experience has shown that a ballasting resistance is absolutely necessary when arcs are maintained across constant potential circuits, and that the resistance should be about equal to that of the arc itself. In regulating the arc one fundamental principle is universally employed and that is the relation between the current and the voltage across the arc. Commercial arcs for lighting purposes usually employ a solenoid in series with the circuit. A plunger fits in the solenoid and carries a friction clutch. With no current flowing the weight of the upper carbon, or a spring if the carbons are horizontal, causes one of the carbons to touch the other. This immediately causes the current to flow, which sucks up the plunger in the solenoid separating the carbons until a balance is obtained. The details of construction and the refinements on such lamps are endless, but all employ all the same fundamental principles. Such arrangements are not, however, satisfactory for searchlights, which require that the maximum amount of light should always be obtained, which in turn requires that the voltage and current be kept almost exactly constant, that the arc be maintained at a constant length, that the carbons burn uniformly, and that the crater be always at the focus of the mirror. Therefore, much more elaborate feeding mechanisms, means of adjusting the carbons, of focussing them accurately, etc., must be provided.

The use of alternating current has been successfully employed for commercial arc lights, and presents the following advantages:

1. Economy of transmission.
2. Uniform burning of both carbons.

On account of the high current employed in military searchlights (130 to 200 amperes), it is necessary that the source of power be located somewhere near the light, as otherwise the line losses and drop would be excessive. This means that a separate generator and prime mover must be installed for practically every searchlight. The use of alternating current therefore presents some very attractive features along this line, since it would permit all searchlights at the same fort to be operated from one or two central stations well protected, the power being transmitted to the lights at comparatively high voltage and stepped down to the required amount at each light. The transformer is a small compact piece of apparatus, requiring practically no attention and could be protected by placing it underground beneath the light. Also, since with alternating current each carbon is alternately a positive and a negative once each cycle, both carbons burn uniformly and the feeding mechanism can be so arranged that the arc would remain in focus at all times, provided the carbons were homogeneous and of the same material. However, there is one very important characteristic of alternating current arcs which virtually precludes their use in searchlights, and that is the absence of a pronounced and stationary crater. The importance of the crater, which furnishes most of the light and causes it to fall on the reflector, was shown in the discussion of the direct current arc. With the alternating current arc only a little over a half of the total light emitted would fall on the mirror and be reflected in the beam, nearly all that given off by the carbon nearest the mirror being sent out in the shape of a cone which would diverge from the main beam shortly after leaving the light. These diverging beams would be even more objectionable than the loss of the light itself.

At the present time there is on the market or being developed in this country the following makes of searchlights:

General Electric Company.
Sperry Gyroscope Company.
Beck.

The general description of the operation and mechanism of these lights has been fully covered by the publications of their makers, but a brief summary of their differences and the advantages claimed for each will be given here.

GENERAL ELECTRIC LIGHT

This light employs ordinary carbons burning in the atmosphere. The positive now used is 2 inches and the negative 1¼ inches in diameter, but smaller copper plated carbons recently produced by the National Carbon Company promise to give better results. Copper plated carbons have been installed for many years in the commercial arc lamps for lighting purposes and it is rather surprising that their use in searchlights has not been adopted before this. Practically all the lights in our service today burn the ordinary carbons. Their disadvantages are as follows:

Carbons are consumed too rapidly.

Carbons require constant attention on the part of the operator to make them burn uniformly.

Carbons are too large, giving a large illuminating area and hence a low intrinsic brilliancy.[1]

Arc is too unstable.

Arc has to be kept in focus by constant observation.

Old type of feed too complicated and unreliable.

The later type of motor feed control developed by the General Electric Company is considered by the writers to be greatly superior to the magnet type but there is still considerable room for improvement, and it is believed that in the future any efforts toward improving a feed control should be along the lines of simplicity and reliability rather than of complexity and unnecessary accuracy and refinement.

SPERRY LIGHT

This differs from the General Electric light in that the arc is cooled by means of an air cooled, copper radiator which surrounds the positive nearly up to the tip. Immediately in front of this radiator is a short tube of fused silica through which about ½ to ¾ inches of carbon is allowed to project.

---

[1] Intrinsic brilliancy is the luminous intensity per unit area.

Air is supplied by a small motor driven blower to this radiator and also to the negative holder. They claim for this light the following advantages:

Cooling of the arc, thus reducing carbon consumption.

Use of smaller carbons with higher current density giving less shadow and greater intrinsic brilliancy.

Experience has not yet demonstrated all the advantages claimed for this light, but no doubt it is much more efficient than those of the General Electric type. If it meets all the claims of the makers, it may prove of considerable interest to the coast artillery as the Sperry Gyroscope Company claim that their light and mechanism can be fitted, at reasonable cost, to the present type of searchlights installed in our coast defenses. Their feeding mechanism operates on the thermostatic principle.

BECK LIGHT

Like the Sperry light, this light employs the principle of cooling the arc, but it is employed in a different manner. For this purpose it makes use of a spray of alcohol or similar hydro-carbon against the hot tips of the carbons. The alcohol ignites, but the temperature of its flame is said to be sufficiently below the operating temperature of the tips to act virtually as a cooling agent. In addition, the products of combustion act as a protective sheath to prevent undue oxidation. They claim for this light the following advantages:

Small positive carbon with high current density and thus high crater temperature throughout the crater area, which gives high intrinsic brilliancy.

Small negative carbon.

Long arc length, that is, distance between positive crater and negative point.

Uniform mixture of carbon so as to help the evenness of burning.

The following, which gives some interesting data, is quoted from Mr. C. S. McDowell's article on searchlights published in the *Proceedings of the American Institute of Electrical Engineers*, February, 1915:

> It is, of course, well known that carbon is the most refractory of all known materials, boiling at about 4000°C., but it unfortunately commences to evaporate at a much lower temperature (about 1800°C.), so that in an ordinary arc very little of the total area of the end of the positive carbon is at the melting temperature, a small wandering spot being the real efficient

part of the carbon, and the rest of the end of the carbon is consumed at a much lower temperature, giving off less intense rays and a longer wave length. This may be readily seen in comparison of the Beck and ordinary arc by the color of the arc.

In the Beck arc the ends of the positive and negative carbons are enveloped in the hydro-carbon vapors which prevent the consumption of the carbon, at a lower temperatures by keeping oxygen from them; in addition it cools the outer shell of the carbons, the gas being at a temperature of about 1000°C., and thus concentrates the current in the center of the carbons—thus a current density greater than 0.75 amperes per square mm. is obtained, and the total crater of the positive carbon reaches a very high temperature. The current is brought to both carbons near the ends by roller contacts so the only part having this high current density is the part protected by the indifferent gas. The positive carbon is cored with a rare earth with a melting point at about 3500°C. The positive develops a deep crater, about 12 mm. deep, filled with incandescent gas. The sides of this crater reflect the light radiation to the focus of this crater and in addition, the light from the negative is reflected, so it is believed nearly true black body radiation is obtained; and by adjusting the focus of the crater to the focal point of the mirror the high peak in the luminosity curve of the beam is thus accounted for.

The area of the Beck positive carbon is 201 sq. mm., the area of the ordinary 36-inch light positive carbon is 805 sq. mm. In the Beck light the maximum intrinsic brilliancy is greater than 438 candle power per sq. mm. The intrinsic brilliancy of an ordinary carbon arc varies from 120 c.p. per sq. mm. to 160 c.p. per sq. mm.

In addition to the black body radiation obtained from the crater, there is evidently a large amount of light radiated from the incandescent gas in crater, of a selective nature. It would probably at first be thought that this gas should follow Kirchhoff's Laws and absorb the lines which they naturally radiated, giving the Fraunhofer lines seen in the sun's spectrum, but in this case the incandescent gas is at a higher temperature than the crater and the spectrum shows positive lines apparently superimposed on the regular temperature radiation.

It is noticed that taking the Beck carbons and starting at a low current density a luminous arc stream as of a typical white flame arc is obtained, the anode being convex. As the current density is increased the anode becomes concave and the anode stream disappears, apparently being confined to the crater of the positive carbon, leaving only the lower temperature and less luminous cathode stream. The temperature of the incandescent gas within the positive crater is estimated to be between 5000 and 5500 degrees Centigrade.

In the above the statement is made that the positive carbon developes a deep crater filled with incandescent gas and also that the sides of this crater reflect the light radiation to the focus of this crater and in addition, the light from the negative is reflected, so it is believed nearly true black body radiation is obtained, and by adjusting the *focus of the crater* to the focal point of the mirror the high peak in the luminosity curve of the beam is thus accounted for. This appears unreasonable and contrary to the opinions of all other authorities on this subject. It is a well known fact that each particle of incandescent vapor as well as each particle of the luminous carbon acts as a separate and distinct source of light, giving off beams in every direction so that there is no reason whatsoever why these various beams of light emitted from different positions and in every direction should be reflected by the walls of the crater to a common focus. However, if this is so it would hold equally well for all types of carbons and is not an exclusive feature of the Beck light.

It appears to the writers that the deep crater referred to above and claimed to be an advantage in the Beck light is really a disadvantage as all experiments seem to indicate that a comparatively shallow crater is to be desired. It is believed that the principle advantages of this light lie in the composition of the carbons and in the small size of the carbons which admit of a high temperature of the crater thereby securing a great volume of light from a small area.

The disadvantages of this light, and these also apply to the Sperry light, are as follows:

Increased complexity of parts.

Increased cost.

Rapid consumption of carbons.

Very long carbons of small cross section, involving great probability of breaking.

Mirrors

The first attempt to use parabolic mirrors was in lighthouses, the mirrors being made of metal. It was found, however, that they had small reflecting power and soon lost their polish. According to various experimenters, the loss of light on reflection varies from 35 to 40 per cent. Glass was then tried, as it is capable of taking on a high polish and when silvered is an excellent reflector. At first all efforts to manufacture parabolic mirrors of sufficient accuracy were unsuccessful, so the mirrors were made with a spherical surface. This necessitated the use of small effective angles, for as soon as the ratio of mirror diameter to focal length exceeded a certain value, the deviation of the reflected light from parallelism becomes so great that no advantage can be gained by increasing the effective angle.

The next step was made by Fresnel, who constructed lenses out of concentric rings and surrounded the lamp with a system of concentric, totally reflecting prisms which transmitted that part of the light falling outside of the lens, in the direction of the axis of the lens. By this means he succeeded in reducing the spherical aberration by suitably choosing the radii of curvature of the lens and in decreasing the amount of absorption through being able to use thinner glass. This system is still used in light-houses, but later inventions have driven it from the field of searchlights.

The next great step in the advance of searchlight reflectors was made by Mangin about 1876. He showed that spherical aberration on reflection from a spherical mirror could be almost entirely avoided by giving the glass the form of a concavo-convex lens instead of making it of uniform thickness as had been previously done. The spherical aberration, however, could only be made negligible when the diameter of the mirror was not greater than its focal length. This meant that the effective angle was only about 60 degrees and the mirror therefore reflected only a small part of the light emitted from the source, so this type was eventually superceded by the parabolic mirror when Schuckert in Nuernberg succeeded, in the year 1886, in manufacturing parabolic mirrors from one piece of glass.

All the reflectors on the market today are of the parabolic form and are made in both metal and glass. Of the former class, two important types have been tried, that invented by Mr. Cowper-Coles and that invented and manufactured by the Sautter-Harle Company.

The first type is made by an electro-plating process and a beautiful polish is obtained from it but it was found that reflectors of this type were quickly affected by atmospheric agencies and especially by the vapor from the electric arc. Even when the mirror is protected by a coating of palladium, or platinum, it is injured after a few hours use. These mirrors have been tried with various navies but apparently have not been successful.

The second type, made by the Sautter-Harle Company is ground and polished from a strong metal alloy, and then covered with a thick layer of gold, burnished and polished. The following advantages are claimed by its makers:

That it resists the action of the arc vapors and the atmosphere without the reflecting surface being at all affected.

That it tarnishes less than the silvered mirror.

That it requires less cleaning and attention than the silvered mirror.

The substitution for the violet beam of the silvered mirror, a beam of yellow giving objects a color more favorable for visibility at a great distance.

The construction of a searchlight entirely of metal (glass being entirely eliminated) so that breakage is unlikely and the mirror can easily be pierced by a projectile without its operation being at all affected.

From tests conducted at the U. S. Engineer School, it appears that the last contention only was borne out. It was found that from the standpoint of illumination, the glass silvered back mirror, though having only 64 per cent of area of beam, and using only five-eighths of the current, gave results equal to either of the two metal mirrors tested. The metal mirror possesses the advantages of ruggedness, immunity to damage through shock or missiles, and lightness; but it is not the equal of the glass mirror in other respects.

The ruggedness of glass mirrors can be greatly increased by cutting them up in segments and supporting them by a metal framework. Experiments conducted at the U. S. Engineer School showed that such a mirror was practically as efficient as a solid one, and that such a mirror would still be serviceable even if one or two segments were shot away, so it seems that this type should be adopted in the service.

There is one defect in the glass mirror, however, which appears to have received scant consideration. The beam cannot be elevated above 30° without danger of hot particles from the carbon falling on the mirror and cracking it. As long as these lights are to be used solely for searching water areas, this is no objection, but it practically precludes their use against hostile air-craft. In case our fortifications were ever endangered by the possibility of such a raid, it would be necessary to either modify our present lights to elevate to any angle or to install a complete new system. As there is considerable space in the center of the mirror which is in the shadow of the negative carbon, and therefore useless as a reflector, it seems to the writers that this section could be removed. This would enable the light to be used a few degrees from the vertical without injury to the mirror; and by covering the lower quarter of the mirror with a thin mica screen, danger could be avoided at all angles of elevation.[1]

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[1] Reports from abroad indicate that in some lights trays or baskets are placed so as to catch the falling particles, and in others a fan motor blows the particles away from the mirror.—*Editor.*

Color of Beam

As regards the best wave length or color to be used there appears to be no definite opinion. Experiments conducted by Captain J. C. Ohnstad, Coast Artillery Corps, U. S. Army, with ultra-violet carbons in which the shorter wave lengths predominated, with a view to obtaining a beam of special penetrating power for foggy and hazy atmosphere, indicated that these carbons were not as suitable for this purpose as those giving longer wave lengths. As 50 per cent of the violet rays and only 25 per cent of the red rays of the sun are absorbed by the atmosphere, it would appear that the red rays are more suitable for searchlights than the violet. The former having greater penetrating power under atmospheric conditions, carbons producing light predominating in the longer wave lengths and as near the red end of the spectrum as possible should be used. While this might not be true for foggy or misty weather the results of Captain Ohnstad's experiments would indicate that it is, notwithstanding the fact that the extremely short wave lengths such as the Roentgen rays will penetrate most opaque substances. This could only be determined by extensive experiments. The experiments conducted with the gold mirror appear to conflict with this theory but the color of the mirror does not affect the total amount of those wave lengths which it reflects but does reduce the total light emitted by the arc in that it absorbs many of the other wave lengths. The total efficiency of the light is therefore reduced a certain amount. Therefore, changing the color of the beam by merely changing the color of the mirror is of no advantage.

The present development of searchlights and the future outlook is discouraging as there seems to be no possible way in which the range of the light can ever be made to equal the range of modern guns. However, it is believed that instead of working entirely to develop visible penetration beyond present ranges of the searchlight, some effort should be made to visualize or utilize the invisible reflected rays which certainly are reflected from the object illuminated by our present searchlight beam. The trouble is not that our searchlights do not penetrate but that the eye is so constructed as to be unable to perceive the rays outside of the spectrum which are reflected from the object. For this purpose the possibilities of the selenium cell or something similar suggests itself and it is thought that the future will see a development in this direction.

CURRENT, VOLTAGE, AND LENGTH OF ARC

For a given current and voltage all authorities agree that there is a certain length of arc which will give the maximum illumination. This length depends upon the nature and size of the carbon and as few recorded tests were run under the same conditions, comparison is difficult. There are, however, certain principles laid down by some authorities among which is the following, quoted from Mrs. Ayrton's *Electric Arc*.

1. The light emitted by the arc in any given direction is roughly proportional to the apparent area of the crater as seen from that direction.

2. On the whole, the light emitted by the arc, by a constant current, increases, up to a certain point, as the arc is lengthened, because the greater distance between the carbons allows more of the crater light to escape.

3. As, however, the negative carbon becomes very finely pointed when the arc is short, with large current, the light emitted by a very short arc is greater than that of the longer one when the current is large.

4. The illuminating power of the arc does not increase indefinitely as the arc is lengthened, with a constant current, but has a maximum value with a comparatively short length of arc some 4 mm. or so.

5. This is probably due to the absorption of the light of the crater by the carbon mist which it traverses before escaping from between the carbons.

6. The fact that the arc does absorb light can be proved in various ways: (1.) It casts a shadow; (2) It hides things placed behind it; (3) The light becomes more purple as the arc is lengthened, as if more of the yellow and green rays of the crater light were absorbed, the longer the arc.

7. When either the length of the arc or the P.D. between the carbons is constant, the illuminating power increases with the current.

8. Only about 10 per cent of the energy supplied to the arc is utilized in producing light.

9. Of the power supplied to the arc only that which is utilized at the ends of the carbons in the crater and the white spot is useful for light giving purposes, that absorbed by the arc itself being practically wasted.

10. When the arc is lengthened, while the current is kept constant, almost the whole of the extra power supplied is swallowed up by the carbon mist, and is practically wasted as far as the creation of light is concerned. Consequently, more light is created for a given power supplied the shorter the arc.

11. Soft carbons give more light than hard for a given amount of power, but they burn away much faster.

12. The most efficient arc is to be obtained with infinitely thin carbons and an infinitely short arc.

13 The ideal condition is most nearly reached when the positive carbon is so thin for the current that the arc is as near as it can be to hissing without being unsteady, when the negative carbon is as small as it can be, to burn the requisite number of hours, and when the length of the arc is such that the ratio "light emitted" divided by the "power developed in the generator" is a maximum for the particular carbon.

14. When the length of the arc is constant the light efficiency increases with the current.

15. The only fair method of comparing two sources of light is to put each into the condition best suited to it, and then to measure the ratio: total light emitted divided by the total power supplied in each.

16. The light emitted by a very short arc is greater than when the arc is longer, with a large constant current.

17. But for the negative carbon stopping some of the light, the ideal condition for an arc would be to have the carbons nearly touching.

If these conclusions are correct, it might be possible to obtain more light by an arrangement of the carbons whereby the shadow of the negative is reduced to a small amount. This might be effected by placing the carbons at right angles and using a magnet to insure the arc entering the positive crater parallel to the axis of the carbon. This method has been used by Siemens, according to Rosh and Tomberg. Such an arrangement might not only increase the candle-power but would greatly reduce the power necessary and also increase the proportion of the longer wave lengths by shortening the arc. Experiments along this line are recommended. The tendency in the more recent lights is to use small carbons, especially the negative, thereby reducing the shadow cast by the latter. This requires high current density and consequently shortens the life.

SHUTTERS

Experience has shown that a searchlight will work at its maximum efficiency only after it has been burning for a considerable length of time. If the light is occulted by breaking the circuit of the arc or reducing the current, two objections at once present themselves: first, the red hot carbon will glow for some time thus indicating the position of the light; second, it will take some time to get the light back into action again under the same efficient conditions that it had when occulted. The only practical way of occulting a light is, therefore, by means of a shutter which will enable the light to burn continuously. Although the absolute necessity for a suitable shutter on all of our searchlights is admitted by all those familiar with their operation, it appears that no steps whatsoever have been taken towards developing and providing such a shutter.

The requirements of a good searchlight shutter are given in Captain Ohnstad's article[1] on carbons and are here quoted as follows:

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[1] JOURNAL U. S. ARTILLERY for September-October, 1914.

1. It should be light-tight to the extent that the position of the searchlight cannot be located with a pair of field glasses at 1500 yards when the shutter is closed.
2. The shutter should be designed to operate quickly under all conditions of wind and weather without the assistance of additional personnel.
3. The design should be compact without projecting parts which would cause difficulties of operation in high wind, heavy rains, or snow storms.
4. It should not reduce the diameter of the beam.
5. It should leave the beam free of all obstructions.
6. It should not be so heavy as to unbalance the light whether opened or closed, nor make it difficult to traverse or elevate.
7. The shutter should not project to the front so as to require an enlargement of the searchlight shelter.
8. The shutter should be so designed as to permit the front door to be opened easily.
9. The shutter should be rugged in design and capable of standing hard usage.
10. The material should be such as not to require frequent renewals.
11. The price should be reasonable, and in no case exceed ten per cent of the cost of the light.

Although several types of shutters have been improvised at various posts, none of these have met all the above requirements. Most of these have been made on the principle of the window blind and necessarily absorb part of the beam. They are also clumsy and flimsy and lacking in uniformity in design. The shutter which appears to meet all the requirements is the "Iris" shutter made by the Siemens-Schukert Company. This consists of an Iris diaphragm constructed on similar principles to those used with photographic lenses, and so arranged that when closed the diaphragm fits into a circular groove in a central stop in the center of the beam. This circular stop, while in the center of the beam, really cuts off no light since the beam emerges as a hollow cylinder due to the shadow cast by the negative carbon. The shutter is operated by a hand lever but an electrical control magnet might easily be designed for this shutter which would enable it to be operated from a distance. This would require but two additional wires in the controller cable. Cut and description of this shutter is in *Searchlights* by F. Nerz.

FEEDING MECHANISMS

The types of feeding mechanisms used on our searchlights have already been discussed under DEVELOPMENT.

In addition to the feeding mechanism, our present type light, burning the carbons which are now supplied, requires an adjustment of its rotating device in order to make the positive carbon burn uniformly. It is hoped that the smaller carbons recently developed by the National Carbon Company will obviate the necessity for the rotating device; but, as long as this device is necessary, it is believed that it should be revolved automatically and continuously and thus relieve the operator of this duty.

An arrangement recommended by Captain Ohnstad whereby the operator can observe the burning of the arc and the position of the focus by means of its image thrown on a piece of paper, should most certainly be installed on every light. This device should be so constructed as to show two separate the images of the arc 90 degrees apart and should be installed on side of the light where the operator is stationed so that he would not have to move from his normal position in order to observe it. This would enable the operator to observe the focus of the light and the condition of the carbons and arc at all times without special effort and thus would insure better operation of the light being obtained.

CONTROLLERS

Many types of controllers have been devised but none of them has proved entirely satisfactory. The first and simplest controller tried was the one most commonly used for operating motors where the distance between the operator and the machine was not excessive. This consists in placing a variable resistance in series with the motor armature and varying the speed by adjusting this resistance. Obviously such an arrangement is limited to comparatively short distances since the whole armature current must pass through the controller wires causing considerable line drop. Experiment shows that this method of control can not be successfully employed on searchlights for distances more than 150 feet without using unusually large conductors.

The controller most generally used in our service is the 7-wire type made by the General Electric Company. It consists essentially of a simple circuit making and breaking device at the controller which controls the current in the conductors. These conductors are connected to a pilot motor consisting of six stationary poles and a revolving armature changing the combination of the currents passing through these poles causing the armature to take up various positions and revolving the drum at the light. This drum carries cams which operate contact fingers to resistances connected to the motors. The circuit making and breaking device at the controller, referred to above, is operated by a drum which revolved in one direction causes the motor to turn in one direction, and if revolved in the opposite direction the motor is reversed. A means of obtaining the approximate azimuth of the light is provided at the controller.

The disadvantages of this controller are as follows:

1. Too many conductors required.
2. Numerous and complex parts.
3. Delicate contact devices which are frequently getting out of order.
4. It requires accurate adjustment to operate properly.
5. The contact plates upon which the contact fingers rest are soon worn away by the sparking, and require replacing.

The device for determining the azimuth is considered to be of little practical value even when it works satisfactorily—which is seldom.

VIRY TWO-WIRE CONTROLLER

A very ingenious controller devised by Captain Viry of the French service is shown in Fig. 1. The theory and operation of this controller is as follows:

The illustration shows the disposition of parts for two movements of the motor *I*. The station of the controller operator at *A* has two vibratory springs *C* which are put in motion by means of the electro-magnet *B*. A single magnet can operate several springs. The vibrating springs *E* of the receiver, which are of tuning fork shape, are put in action by the electro-magnets *F* which receive the intermittant current sent out by the transmitter. The spring of the receiver is tuned with the spring of the transmitter and operates in the same period with it. The spring *E* of the receiver vibrating strikes the catch *G* and releases the lever *H* which being pulled down by means of the spring shown, completes the circuit allowing current to flow from the line through the motor *I*. The direction that the current flows through the motor will depend upon which of the levers *HH* is tripped. To stop the motor, all that is necessary is to push down the third key of the controller sending current through the solenoid *K*. This current pulls down the rod *D*, and the cross piece *J* striking the ends of the lever *H* breaks the circuit and arms anew the catch *G*. The apparatus is so constructed that a continuous current

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wires from the controller to the light, thus admitting of control from any distance. The circuit and operation are as follows:

This controller is operated by means of a key which by proper movement closes the circuit from a few dry cells to leads of two wires and the ground to one of two polar relays on a switch-board near the light. One relay is for horizontal, and the other is for vertical movement. The armature of a polar relay closes the circuit through either of a pair of solenoids of the horizontal or vertical reverse magnets. The magnets are energized from a 110 volt circuit. The core of whichever magnet is energized is drawn up and operates the handle of a reversing switch. This switch closes the circuit through the motor armature and a resistance in series with it. The current flowing in the armature circuit is just under the amount required to start the motor. When the switch of the controller is released the circuit of the reverse magnet is broken and the core falls. On again operating the key of the controller in the same direction the same core of the same reverse magnet raises and carries with it this time a circuit closer. This circuit closer cuts out in succession four resistances which are in parallel with the resistance in the motor armature circuit. Variations in speed are obtained by opening and closing the circuit by means of the key on the controller. A number of resistances are supplied with the controller, the ones to be used for the particular light being determined by trial.

The advantages of this controller are simplicity, few wires, and small current to operate it. While it is stated that this controller is not uniformly successful, it is believed that in the majority of instances where it has not operated satisfactorily the failure was due to not using the proper resistance with the controller for the particular light in question and in not properly adjusting the relays and contacts. If the intercices between the resistance contacts are allowed to become filled with dirt, etc., satisfactory operation cannot be expected.

Its disadvantages are as follows:

It requires two polar relays each employing delicate jewelled bearings and contact points similar to the bearings in the ordinary Weston ammeter. Such an arrangement necessarily is apt to get out of order and can only be repaired by an expert, who is seldom found at a coast artillery post.

The motor is operated by a series of impulses rather than by a continuous current, and uniform speed regulation is therefore difficult to obtain.

FIVE-WIRE CONTROLLER

It is seen from the above that the disadvantages of all controllers such as are now used lies principally in the use of many contacts and moving parts which frequently get out of order. The requirements of a searchlight controller should be as follows:

1. Freedom from moving parts.
2. Freedom from delicate contacts.
3. To be capable of giving uniform increments of speed between the minimum and maximum values.
4. To be capable of satisfactory operation at least one mile from the light.
5. Should not require an unusually large number of conductors.
6. Should not require conductors of excessive cross section.
7. Should be reasonable in cost.
8. Should be comparatively simple.
9. Should be absolutely positive in its action.
10. Should require practically no care or knowledge on the part of the operator.

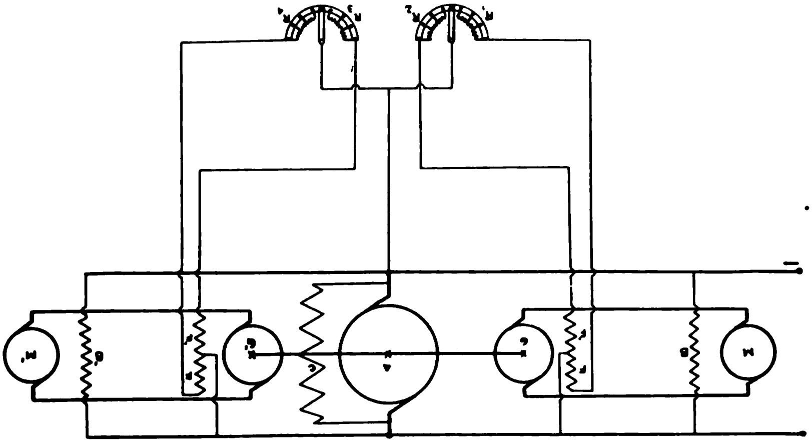

FIG. 2.

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A controller has been designed by the writers to meet as many of these requirements as possible. A diagram of this controller is shown in Fig. 2.

This controller is based on the Ward-Leonard system of motor speed control with suitable modifications to meet the special conditions required.

Referring to Fig. 2, *A* is a shunt-wound motor of approximately 1 h.p. connected directly across the circuit supplying the power to the searchlight. This motor is directly connected to two generators *G* and *G′* of approximately ½ kw. each but for reasons given later neither is ever made to develop more than half its greatest capacity. The armatures of these generators are connected directly to the armatures of the elevating

s M and M', the fields of the latter being
e same circuit as that of the motor A.
nerators G and G', which are shunt-wound,
ff at their middle points and connected to
r. Their terminals are led to the controller
resistances R_1, R_2, R_3, and R_4 as shown in
he negative bus bar is connected through a
to the resistance arms, there being but one
nerator. When the arms are in the positions
diagram the fields of the generators are open,
only the voltage due to residual magnetism is
d this is not sufficient to start the motors M and
mple, suppose that the arm controlling the fields
tor G is moved to the first contact of R_1, the circuit
ed through the field F and the generator generates
a certain polarity and of a certain amount depending
esistance of R_1. This resistance is so designed that
the resistance of the leads, the minimum speed of
r M would be obtained. As the arm is moved still
o the left cutting out parts of R_1, the motor M increases
d and becomes a maximum when all of the resistance
out. If now this arm be moved to the right instead
the left, the field F_1 is closed and a voltage is generated
posite polarity causing the motor M to revolve in the
site direction. The resistance arms are held in the off
tion by springs. The resistances R_1, R_2, R_3, and R_4 each
tain many steps so that practically any desired speed of
e motors can be obtained.

While the generators G and G' could be especially designed or this purpose, this is not at all necessary. By making them of twice the actual needed capacity and winding the armatures to 220 instead of 110 volts, no changes need be made in the field windings other than to connect them up as shown in the diagram. Thus, only one-half of the field windings are in use at the same time; but with the 220-volt armature, full voltage is generated. These generators are made to develop ¼ kw. each although they are made for ½ kw.

The great advantage of this control over the first method described in this paper lies in the fact that only the field current of the generators is sent through the controller leads. As this is small compared to the armature current of the motor the IR drop in the leads is greatly reduced thereby permitting control from a distance far greater than can be obtained by the first method. This distance will depend upon the resistance of the generator field and the size of the controller leads. No exact data in regards to the field resistance of generators of this size is available but judging from the resistance of machines both larger and smaller than this, it is estimated that the resistance will be not less than 150 ohms. Now assuming that it is 150 ohms and that the voltage impressed on the field is about 90, which is about normal for a 115-volt generator, the maximum field current will never exceed .6 ampere. The voltage impressed on half the field will be but 45 volts, and as there are at least 115 volts available for energizing half the field, there will be 70 volts available for overcoming the drop in the leads, and from ohm's law $(R=E/I)$ the resistance of the leads may be as much as 117 ohms. Assuming that the controller is at a distance of one mile from the light we find, by entering the wire table, that No. 21 wire B.S. will be sufficiently large. If No. 16 wire be used, which is the size used in multiple cable, the maximum distance at which satisfactory operation may be obtained may be extended to about four miles which it is believed is as far as tactical requirements will ever demand.

No exact figures are available in regard to the cost of such a motor-generator set, but from catalogs on hand the following prices are estimated:

1 110 volt, shunt wound, 1800 r.p.m. motor	$ 75.00
2 ½ kw., 110 volt, 1800 r.p.m.s.w., generators	120.00
2 Double field rheostats, 0.6 amperes	30.00
Total	$225.00

While the cost of the General Electric controller or the Le Blank controller is not known, it is believed that the former will be at least equal to the cost given above. However, even if the controllers used at present are cheaper, the tactical importance of being able to operate searchlights satisfactorily from a distance is such that cost should be of secondary importance.

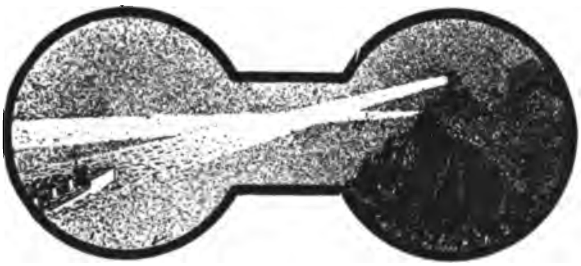
The design of the rheostats will depend somewhat upon the distance and size of the conductors but it is believed that a suitable design which will operate satisfactorily under all conditions can be developed which will obviate the necessity of having more than one size.

The motor-generator set described above could, and preferably should, be placed in the power-plant rather than at the searchlight provided this distance is not excessive.

Referring to the desiderata for a searchlight controller given under 5-WIRE CONTROLLER, it is seen that this method of control satisfies all the requirements with the possible exception of cost which would be of minor importance.

On account of the shortness of the time allotted for investigation of such an extensive subject, details have been barely touched on and general principles only have been considered. The writers are convinced that the development of the searchlight is far from being perfected, and in this discussion they have endeavored to suggest a few lines along which some improvements might be made and experimental investigation carried out.

Practically the only demand for high grade searchlights is by the services, and consequently we cannot expect commercial concerns to spend their time and money in developing something which they have no assurance that the Government will ever adopt; therefore it devolves on the Government itself to develop its own searchlights as well as many other things of which it is the sole purchaser and in this connection it is recommended that suitable officers be detailed to make a special study of this subject and that a suitable laboratory be provided at Fort Monroe, Va., for experimental purposes along these lines. The Coast Artillery Corps possesses officers capable of designing such apparatus and enlisted specialists capable of constructing it provided money and suitable facilities are furnished.



THE USE OF KEROSENE AND ALCOHOL IN THE GASOLINE ENGINES INSTALLED IN THE FORTIFICATIONS OF THE UNITED STATES[1]

BY CAPTAIN CHARLES O. SCHUDT AND FIRST LIEUTENANT JOHN W. WALLIS, COAST ARTILLERY CORPS, U. S. ARMY

The possible use of alcohol is very remote for the following reasons:

1. Its scarcity makes it unlikely that a sufficient quantity will ever be found available for use in emergency.
2. Its minimum cost of production from waste is twenty-five cents per gallon, while the power obtainable is but two-thirds that obtainable from gasoline unless alterations are made in the engines.
3. It would require a reduction in cylinder clearance to increase the compression to about 180 lbs. for efficient combustion. This would result in high maximum pressures and would necessitate additional split-rings to prevent loss of power.

For the above reasons and because of the very short time available, no actual tests with alcohol were made.

Taking up now the question of the use of kerosene, it is a well-known fact that it is cheap, can be procured in any quantity and in any locality in the United States.

Inasmuch as all of the engines in which it is proposed to use kerosene were originally constructed to use gasoline, a comparison of the two fuels is desirable.

One pound of gasoline vapor at 62° F. occupies 4.2 cu. ft., while the same quantity of kerosene vapor at the same temperature occupies but 2.5 cu. ft.

The theoretical amount of air required for the complete combustion of one pound of gasoline vapor is 198 cu. ft., while for the same quantity of kerosene the quantity of air required is 190 cu. ft.

Both fuels have approximately the same B. th. u. value, but the great difference lies in their relative volatility, the boiling points of gasoline and kerosene being approximately 70°C. and 150°C.

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[1] Thesis prepared at the Coast Artillery School.

The methods used by some of the successful manufactures of kerosene engines will now be briefly outlined.

The engines chosen as types may not be the best of their respective types, but were chosen because the writers were familiar with their construction and method of operation.

Volume Governed Engines

The engine chosen to represent this type is a Fairbanks-Morse Type N oil engine, and is made in sizes from five to eighty horse-power.

These engines are single-cylinder engines and the carburetor is set as close to the intake valve as possible.

Provision is made to pre-heat the intake air by means of a sleeve around the exhaust pipe and its temperature can be varied at will by admitting a certain amount of cold air.

The carburetor is an ordinary spray carburetor, the fuel and air mixture being controlled by a butterfly valve which is governed by a flyball governor.

Provision is made so that the engines are started on gasoline and the fuel is changed to kerosene when the cylinder becomes hot.

Provision is also made for starting on kerosene by vaporizing the kerosene before it enters the cylinder.

Water injection is used on all ten horse-power and larger engines, or it might be stated that water injection is used when the speed of the engine is less than 300 r.p.m.

The amount of water injection can be varied.

Hit and Miss Governed Engines

The engine chosen for this type is the engine in use on the Hart-Parr tractor.

This is a two-cylinder engine but each cylinder is complete in itself in that it has its own intake, carburetor, and water spray.

The carburetor is simply a short horizontal pipe with two openings on the lower side that are closed by needle valves.

The fuel is fed through one of the needle valves and water through the other, the water valve being nearest the cylinder.

Two bowls with floats keep both water and kerosene at a constant level, this level being about one inch below the bottom of the intake.

The above arrangement permits the amount of water and fuel to be varied in each cylinder independently, the manufacturer's instructions being to admit only sufficient water to prevent knocking.

Practical Tests

Tests were made on the following engines in the laboratory of the Coast Artillery School.

a. Lathrop single-cylinder, two-cycle marine engine.

b. Ferro single-cylinder, two-cycle, three-port portable engine.

c. Engine attached to 5 kw. generating set; this is a four-cylinder, four-cycle stationary engine.

d. Engine attached to 25 kw. generating set; this is a four-cylinder, four-cycle stationary engine.

The results of the tests were as follows:

LATHROP MARINE ENGINE

This test gave rather perplexing results. The engine had been operated many times perviously on gasoline using a Pony brake load at a speed of about 380 r.p.m. When the fuel was changed to kerosene the operation was not satisfactory, the cylinder knocking at times and the speed being unsteady.

The governor was then adjusted to give a speed of 525 r.p.m., no change being made in the needle valve or air intake spring, when a load of 33 lbs. at a radius of 24 inches was registered by the brake.

The fuel was then changed to kerosene while the engine was running and the speed immediately went up to 550 r.p.m. while the load on the brake arm remained at 33 lbs.

With the same adjustment, the engine for a considerable time carried a load of 40 lbs. on the brake arm.

The engine was operated for approximately two hours when the operations were suspended and the adjustments left as they were with a view of making a test-run a few days later.

Upon attempting to make the test-run, the engine was started on gasoline and warmed up as before until the cooling water was about 80°C. The fuel was then changed to kerosene but instead of running as before with increased speed, the speed dropped and became erratic and the engine finally stopped.

Four days were spent in an endeavor to reproduce the operation obtained on the first day but with only partial success. The engine was completely disassembled and all adjustments carefully checked but at no time was it possible to obtain more than seventy-five per cent of the power obtained on the first day.

The Pony brake is not satisfactory for testing an engine of this kind; for when the speed falls off slightly, the torque seems to increase and before the load can be released the engine stops.

A water load similar to the actual working conditions of the engines when installed in a boat would be better as with decrease in speed the torque of the propeller would decrease thus giving opportunity for carburetor and air valve adjustments.

An attempt was made to give this engine an electrical load, but the apparatus on hand was not suitable.

It is believed that the operation of this engine on kerosene as installed will not be possible except in the hands of highly skilled operators.

It is probable that the principal reason for the failure of this engine to operate more satisfactorily is that it has an excessive crank-case clearance thus resulting in low crank-case compression and permitting the fuel to separate from the air and settle while the mixture is in the crank case. This can be better understood by remembering that the fuel is not vaporized but at best is only carried into the cylinder in the form of spray or fine droplets. It can be seen that if this mixture is not kept moving at a high rate of speed, the fuel will separate from the air and settle.

That the fuel actually separates from the air is proven by the fact that is accumulates very rapidly in liquid form in the crank case.

This theory is further substantiated in the operation of the Ferro engine, a description of which follows.

FERRO THREE-PORT PORTABLE ENGINE

This engine is very similar to the Lathrop except that it is a three-port engine.

This engine was started on gasoline and when the cylinder was warm the fuel was changed to kerosene.

The only change in adjustment was a slight increase in the opening of the needle valve to make the engine operate satisfactorily.

When hot, the engine could be started on kerosene, and with the crude methods available for measuring the power output, the engine appeared to develop as much power on kerosene as on gasoline.

On the day of the test-run with this engine, the total continuous operation on kerosene was four hours or so, approximately full load being on the generators. At the end of the experiment, the spark plugs were removed and examined for evidence of carbon, but they were clean and hence it was assumed that there was no carbon elsewhere in the cylinders.

ENGINE CONNECTED TO 25 KW. GENERATING SET

This engine has a very long and exposed intake manifold and the air and fuel mixture makes six 90° changes in direction before it reaches the intake valves.

The engine was started on gasoline, and when the cooling water had arrived at a temperature of about 80° C., the fuel was changed to kerosene.

Various adjustments of the needle and air intake valves were made in an attempt to get the engine to run steadily and carry a full load, and at the same time to reduce knocking in the cylinders.

There were two positions of the needle valve and air intake at which the operation was fairly steady; one with the needle valve at $4+1$ and the air intake 6 notches from S; the other with the needle valve at 6 and the air intake valve fully open into the crank case.

With the needle valve at $4+1$ and the intake at six notches from S, a load of 210 amperes at 110 volts was obtained, the spark being fully advanced. The engine operated steadily at this load, but would carry no more without great fluctuation in speed.

With the needle valve at 6, and taking air entirely from the crank case, the spark being half retarded, the engine carried a load of 230 amperes at 110 volts and ran steadily. Also in this case when the load was increased much beyond 230 amperes, the speed would fluctuate.

Under both of the foregoing settings the exhaust was very black, and any attempt to reduce the fuel supply caused excessive knocking in the cylinders.

Cylinder No. 4 was especially persistent in knocking and this was to a great extent remedied by lengthening the exhaust valve rod which caused the exhaust valve to close later in the cycle. In fact any knocking could be entirely eliminated by this method, but after going beyond a certain point, the available power was reduced to such an extent that the speed would fluctuate.

After a time, ignition troubles began to appear and upon careful examination it was found that the kerosene had so much lubricating oil mixed with it as to be plainly visible. It was also found that the intake air was taking one pound of lubricating oil per hour from the crank case. The spark plugs were badly carbonized and had to be cleaned before resuming operations.

Operations were now suspended until a clean supply of kerosene could be obtained. In the meantime the following changes were made in the air supply with a view to obtaining clean hot air and at the same time to permit its temperature and quantity to be varied.

The hot-air intake was removed and a piece of tin bolted over the opening to the crank case to prevent oil from being splashed out. The air-valve body was then removed and a thin tin disc inserted in its bottom below the air valve. This disc prevented any air entering the air valve except through the hot-air port.

The air valve was then replaced with the hot-air port opening out away from the engine, the port being connected to an improvised air heater on the exhaust pipe by means of a 3-inch tin pipe. Thus any air entering the carburetor entered by means of the hot-air port and the quantity could be governed. The degree of heat of the intake air could also be controlled by placing the heater nearer or farther from the exhaust pipe. A small hole was made in the tin pipe at the intake valve to admit a thermometer.

Upon operations being resumed with clean kerosene and clean, hot-intake air the operation of the engine was much improved but not yet as satisfactory as desired. Some knocking was still evident and the speed varied slightly.

Water injection into the air intake was then resorted to. This eliminated the knocking, but the flow of the water to the individual cylinders could not be governed due to the length and number of turns in the intake manifold. Most of the water seemed to go to the end cylinders and when sufficient water was admitted to stop knocking in the middle cylinders, the end cylinders would get so much water that they would not fire. As there was no way in which the water supply to each cylinder could be controlled without alteration of the intake manifold, the method of preventing knocking by water injection was abandoned.

The remainder of the experiment consisted in reducing the knocking to a point where it was not believed to be injurious. This was accomplished by manipulating the fuel and air valves on the carburetor. The exhaust valves had been, previous to this last experiment, adjusted in the manner prescribed and were further adjusted during operation to assist in eliminating injurious knocking.

It was found that the speed was steadier when a slight excess of fuel was supplied. With a needle valve setting of 6, the hot-air intake half open, air temperature at intake 51°C., cooling water at outlet 75°C., a load of 240 amperes at 115 volts could be carried. The load could be thrown on and off at will. The searchlight was then operated for about an hour without difficulty, the load being 225 amperes at 115 volts including the cooling fan load.

The Standard Engine

This is the engine installed throughout the service in the old style distribution box boats. It is a two-cylinder, four-cycle marine engine of old design with cylinders of 6-in. bore and 8-in. stroke and is rated by the builders as from 16 to 18 horse-power at 350 r.p.m.

It was originally not intended to test this engine because its long exposed intake pipe seemed to preclude any possibility of satisfactory operation on kerosene. However, from the very beginning of the test, indications were that its operation on kerosene would be entirely satisfactory.

The engine was started on gasoline and operated under normal load with normal gasoline adjustments for about ten minutes. The fuel was then changed to kerosene and the needle valve opening increased fifty per cent. The change to kerosene fuel was accompanied by a material increase in speed and brake horse-power. After an hour's operation with the foregoing adjustments, a series of experiments with various adjustments was begun with results as follows:

The engine developed a greater brake horse-power on cold-air intake than on hot-air intake with either kerosene or gasoline.

The needle valve setting for the most satisfactory operation on kerosene was fifty per cent greater than for gasoline.

The maximum of 18.75 brake horse-power was developed on kerosene with cold-air intake at 460 r.p.m.

To determine whether the engine would "idle" satisfactorily on kerosene, it was operated for fifteen minutes with compression released and spark fully retarded. At the end of this time the load was thrown on, but one cylinder missed and the engine would not come up to speed until a little gasoline was squirted into the air intake. This gasoline caused the missing cylinder to immediately resume firing and the engine to come up to speed. The operation was then continued at the maximum load for one hour with perfect satisfaction.

The engine was then shut down and water at 13° C. circulated through it for two hours in order that the engine might become thoroughly cool. The carburetor bowl was filled and the engine primed with gasoline. The engine was then started, full load thrown on at once, kerosene feed opened, and the engine continued to operate satisfactorily.

The operation on cold air was accomplished by removing the connecting pipe at the carburetor.

Satisfactory ignition at high speed was accomplished by an additional spring on the contact breaker, this device having been designed and installed by Electrician Sergeant Bingham some time before these tests were contemplated.

Due to the fact that the engine was operated at higher than its rated speed, the tension of the springs on the inlet valves had to be increased to prevent escape of fuel back through the intake pipe and carburetor during the first part of the compression stroke.

From the fact that the temperature of the cooling water used throughout this test was 13° C. or 55° F., it would appear that no change in the water cooling system is necessary for satisfactory operation on kerosene.

The exhaust smoke was fairly clear indicating that the combustion was good and consequently little probability of carbonization troubles.

It is believed that the satisfactory operation of this engine on kerosene was due to the following:

The disadvantage of a long exposed intake pipe is counterbalanced by the fact that there is but one bend in the exposed part of the intake pipe and this bend is of long radius; further, the intake pipe is vertical and any fuel that separates from the air will gradually work downward and be again atomized and carried back to the cylinders in a form more suitable for combustion.

In conclusion, it might be stated that the tests made were not extensive. However, from the very satisfactory operation under the adverse conditions simulated during the test, it is believed that the men now in charge of these engines could operate them satisfactorily on kerosene.

Due to the higher temperature of combustion when kerosene is used for fuel, the cylinder lubricating oil ordinarily used in gasoline engines is not suitable.

CONCLUSIONS

From the limited tests conducted, it is believed entirely practicable for the enlisted specialist now in charge of these engines to operate them without very much difficulty. It must be borne in mind that the adjustments for each engine will vary somewhat, and the men in charge of these engines should operate them at times with kerosene in order to familiarize themselves with the difficulties to be overcome.

One of the important things encountered in the test was the mechanical inaccuracy of the valve timing. As stated before, the valves were timed in the manner prescribed and the setting was then checked on the flywheel. The angle past center at which the exhaust valves opened varied 9° and the intake valves varied 7°. It is true that at this time the piston has very little motion, but this error in the cams caused trouble with kerosene fuel.

At this time it might be well to state that at no time was the knocking due to pre-ignition. Any knock could be immediately stopped by short circuiting the spark but, if the knocking were due to pre-ignition, short circuiting the spark would have no effect. Also, knocking was accompanied by the best combustion. In other words when all or most of the cylinders were knocking, the exhaust was nearly clear. Knocking could be increased by shutting the needle valve.

The foregoing can be understood when it is borne in mind that the velocity of flame propagation is greatest when the amount of fuel and air is such as to make complete combustion possible without excess of either. It is also believed that the velocity of flame propagation of a kerosene air mixture is greater than is the case with gasoline. Hence, a spark advance that will work well with gasoline will cause a decided knock with kerosene, unless the rapidity of combustion is retarded by an over-rich mixture. Attempts were made to reduce the amount of fuel with a view to slowing up the combustion, but the engine would not carry the load under these conditions. The fact that the kerosene enters the cylinder as a rain or mist and not as a vapor will in part account for some of the difficulty.

The following increase the knocking: advancing the spark; increasing the compression; making the mixture leaner; reducing the temperature of the intake air; and reducing the speed; and vice versa.

The following construction seems to favor the use of kerosene in gasoline engines:

a. High speed of gases from carburetor to cylinder.
b. As short and straight an intake as possible.
c. Preheating the air supplied to the carburetor.
d. Heating the intake by surrounding it with hot water or exhaust gases.
e. Water injection when piston speed is low.
f. Separate carburetor for each cylinder on large size engines.

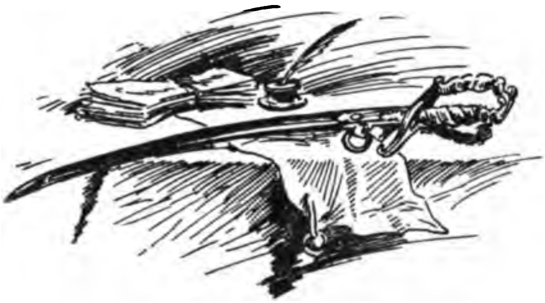
The limited time available for conducting the tests permit the possibility of somewhat different results being arrived at by other investigators. It is believed that this subject should be further investigated by members of the next year's class in view of the fact that this subject is now attracting much attention commercially due to the present high cost of gasoline, and it is to be expected that time will bring a solution of the problem.

List of Cylinder Lubricating Oils for Kerosene Engines

This list was furnished on request by the International Harvestor Corporation of Chicago, Illinois.

Special Tractor Gas Engine Oil—The Sun Company, Chicago, Ill.
Stanolind Gas Engine Tractor Oil—The Standard Oil Company of Indiana.
Eagle Gas Engine Tractor Oil—The Standard Oil Company of New Jersey.
Stanocola Gas Engine Tractor Oil—The Standard Oil Company of Louisiana.
Mutual C Tractor Oil—Mutual Oil Company, Kansas City, Mo.
Socony Gas Engine Tractor Oil—The Standard Oil Company of New York.
Imperial Gas Engine Tractor Oil—Imperial Oil Company, Ltd., Toronto, Canada.

Knox Auto Tractor Oil—Noble Refining Company, Cleveland, Ohio.
Superior Gas Engine Oil—Magnolia Petroleum Company, Dallas, Texas.
Mangolene Tractor Oil—Magnolia Petroleum Company, Dallas, Texas.
Monoline Oil—Montana Oil Company, Helena, Montana.
Diamond A Gas Engine Oil—Pierce Fordyce Oil Assn., Dallas, Texas.
Grange Tractor Oil—Paragon Refining Company, Toledo, Ohio.
Mobiloid Zeta Heavy—Vacuum Oil Co., Rochester, New York.
Union Tractor Oil—Independent Oil Co., DeKalb, Illinois.



THE SUPPLY OF AN ARMY[1]

BY CAPTAIN JAIRUS A. MOORE, COAST ARTILLERY CORPS, U. S. ARMY

It is intended that these remarks shall, as far as possible, be general statements of elementary facts rather than detailed or technical discussions of theories, past or present, pertaining to one of the most important branches of the art and science of war.

The nature and extent of the problem of the supply of an army is, moreover, such, that any brief discussion of it must necessarily be very general and very elementary.

The principal factors of the problem are:

1. The procuring of the supplies by purchase, by manufacture, or other methods.
2. Their storage, including care and preservation at suitably situated localities or depots.
3. Their transportation, delivery, and issue to troops in the field.

The efficiency of an army depends, to a very great degree, upon the manner in which the individuals responsible for the three factors just enumerated perform their duties.

Battles may be directly decided by tactics, logistics, strategy, or morale; but the men, the horses, and the guns must be fed and cared for, before, during, and after the fight, and the victorious general must always bear in mind a great soldier's saying that "an army travels and fights on its belly." An adequate and properly administered supply system is essential to military success.

Lack of supplies (Russia in Poland, July and August, 1915) may check an army in its victorious march and bring it to defeat, disaster, or total destruction. History cites innumerable examples of military failures and reverses due to failure of the supply departments.

Supply officers (and all others responsible for or concerned in the welfare and success of the army) should never forget that it is their duty to see that the army in the field is always supplied with the best food, the best equipment, and the best munitions obtainable; but the soldier must also do his share and remember that it is his duty to expect reasonable and unavoidable deficiencies in food and other supplies, with the hardships incident thereto, and that good troops (the kind that win battles) have always done this.

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[1] A Lecture Delivered to the Students' Training Camp, Presidio of San cisco, California, 1915.

I wish, at this point, to call attention to the views of some of the greatest soldiers as to the importance of supplies.

Napoleon held that the ability to bear hunger and hardships successfully was the highest test of the soldier; and Frederick the Great said hunger was the worst and most dreaded of all the soldier's enemies. Napoleon says further, however, in this connection, "It is impossible to employ too many means of furnishing us with provisions. Everything lies in that. My situation depends on food and I am victorious when I have it."

The importance attached to an efficient supply service by Napoleon, who was as great a rustler as he was a general, is a matter for careful reflection. He was wonderfully successful when badly handicapped by lack of supplies, but even then he made, so to speak, a psychological use of the supplies he did not have by dangling them before his soldiers' eyes and telling them, by clever proclamations, how good and abundant they were and that all they had to do to get them was too fight a little for them.

Assuming then that the victorious army must be well armed, well sheltered, and well fed, let us consider in a general way the theory and practice of army supply.

Military history records innumerable attempts to solve the supply problem for an army in the field by various systems of fixed regulations, and it records also that these systems have invariably failed and failed miserably.

The following has recently been submitted by one of Europe's greatest generals and military students and may be taken as a correct solution of the problem.

> The question of supplying large armies in the field during active operations may be looked upon as a problem as yet in the main unsolved *and moreover as one that will always remain unsolved.*

The United States, like all other countries, has made attempts to solve this problem for the Army from time to time and it may be desirable in passing to note one or two comments on our former efforts and then consider some of the details or departments of the supply system as it exists at present in our service. It is probably a matter of common knowledge that the number of European observers and critics who wrote more or less extensively on the Civil War in the United States was legion, and that their comments were frequently, and often justly, not over-complimentary to the tactical, strategical, and administrative ability of the military authorities. However, their comments on the supply system are almost invariably favorable and they frequently expressed not only great admiration for its efficiency but marveled exceedingly that it could do all that it did do and do it so well.

How well we did things in the early days of the Spanish-American War in Cuba, may be judged from the following quotation from Lieutenant-Colonel (now Major-General) Henry G. Sharpe, Q. M. Corps.

> If we had had at the outbreak of the Spanish-American War a set of Regulations, carefully drawn, * * * describing the functions and duties of supply officers and had such officers been familiar with the same, * * * it is improbable that the correspondent of the London *Times* would have been justified in writing his paper that (using the word Commissariat as applied in the British army) "The Commissariat is a huge joke."

In some ways I am disposed to concur with many foreign officers, with whom I have discussed this matter, in their criticism, which is that we feed so well in garrison that our soldiers are spoiled for the field rations.

I recall that this was a frequent comment of the Japanese officers, who in calling attention to their own plain but excellent ration (from the Japanese soldiers' standpoint at any rate), laid especial stress on the fact that their men always get the same food in garrison or in the trenches, no matter where they are, and accordingly they never have to suffer from the effects of being temporarily deprived of their accustomed manner of living.

To proceed to our own supply system, which in many ways is organized and operated much like those of other countries, we may say that the supply of the U. S. Army is at present administered by:

1. The Quartermaster Corps, or Supply Corps proper, charged with the subsisting or feeding, the clothing, the sheltering, the paying, and the transportation of the army.
2. The Ordnance Corps, charged with furnishing arms

and ammunition of all sorts, and accessories and equipment of certain classes pertaining directly thereto.

3. The Medical Corps, charged with the furnishing of medical supples and their accessories as well as medical attention and advice.

4. The Engineer Corps, which at times procures and disposes of immense quantities of engineering material and accessories.

5. The Signal Corps, charged with the supply of signal material, including telephones, telegraph and radio instruments, searchlights, aeroplanes, etc.

In the United States, as elsewhere, the supply service in general is divided into two distinct parts or spheres:

1. Supply service in rear of the army. This is closely allied to and in many ways identical with supply service in in time of peace.

It includes, as heretofore noted:

a. The procuring of supplies by purchase, manufacture, etc., and their storage, care, and preservation at suitably located main or base depots.

b. Their transportation and distribution.

2. The most important and most difficult part of the supply service, the supply of the army in the field in time of war.

Under the first part or sphere, supply service in rear of the army, or in time of peace, the methods of procurement are:

a. By purchase.
b. By manufacture.

(a) By Purchase

DIRECT DELIVERY BY CONTRACTOR TO TROOPS

Disadvantages

The contractor may be dishonest or unscrupulous. He may be indifferent. He may be, and often is, ignorant as to what the real needs of the army are. In any case he furnishes whatever he sees fit. The State pays for the best and gets the worst and the army suffers discomfort, discontent, sickness, and possibly defeat and disaster as a result of this badly regulated or more properly non-regulated method of supply.

DELIVERY THROUGH SUPPLY OFFICERS, REGULATED BY SPECIFICATIONS, PROPOSALS OR BIDS, OR BY CONTRACTS

Advantages

The specifications are, or should be, so drawn as to fully protect the State and the army which uses the supplies.

The proposals or bids stimulate competition and consequently low or reasonable prices are obtained. The contract, if the deliveries are carefully inspected by competent and trustworthy officials, assures to the State the supply of what it is paying for and what the army really requires.

(b) BY MANUFACTURE

ADVANTAGES AND DISADVANTAGES

Supplies may frequently be better and more economically obtained by manufacture in government owned plants than in establishments controlled by private individuals.

It is impracticable, however, to maintain government plants to supply the army, even in time of peace; and it is particularly necessary, because of the peculiar needs of the army and the special qualities required in its supplies (frequently quite different from those of the similar commercial staples), that private concerns in sufficient number to supply any and all demands, whether in peace or in war, become familiar with the needs of the supply department of the army.

The commercial shoe does not fulfill the requirements of the service. The shoe manufacturer must have special knowledge and equipment to make satisfactory military foot wear. The commercial rifle is not necessarily a good army weapon, and it has recently been demonstrated that so small a part of the military rifle as the firing pin can not be made by a regular private arms manufacturer without a lot of special instructions and experience. Similar examples may be quoted indefinitely. The point which it is desired to establish, with reference to this matter, is that we should have as many private manufacturers as possible familiar with the peculiar nature of army supplies and able to produce enough of them for the use of the army in any emergency.

BASE

Reserves of men and supplies of all sorts are obtained by an army from its base.

The greater the size, and the more extensive the resources of the base, the greater its importance and value to the army.

It should accordingly be as extensive and rest on as many points as possible to avoid undue concentration of supplies at any one point.

DEPOTS

These are classified as main or base depots; secondary or intermediate depots; supply depots or field bases.

MAIN OR BASE DEPOTS

1. *Quartermaster Corps.*
   Subsistence, including beef herds or corrals.
   Remount and motor transport depots.
   Clothing, tentage, cooking utensils, etc.
2. *Ordnance.*
   Arsenals, steel plants, arms and mamunition factories, etc.
3. *Medical Corps.*
   General hospitals, medical supply depots, etc.
4. *Engineer Depots.*
5. *Signal Corps Depots.*

SECONDARY OR INTERMEDIATE DEPOTS

For 1, 2, 3, 4, 5, at ports of embarkation or disembarkation. Secondary bases, etc.

SUPPLY DEPOTS OR FIELD BASES

For 1, 2, 3, 4, 5, in the field of actual operations.

TRANSPORTATION

Transportation includes railroads, their capacity, condition, operation, and maintenance; roads of all sorts; autos of all types; wagons and animals; pack trains and coolies.

Water transportation of every sort are all factors of vital importance in the solution of the supply problem; and factors which, if not properly utilized, may seriously impair or even destroy the supply service.

RESOURCES OF THE COUNTRY

All possible information as to the resources of the field of operations should be obtained in advance.

Napoleon in discussing this matter with his supply officers said,

> It ought not be necessary, as it is, for me to remind you of the folly and extravagance of bringing from Paris supplies which can be obtained better and more cheaply in Munich.

Not only the question of the food ration, but the forage ration, water, fuel and shelter, transportation, etc., should be carefully investigated in determining the extent to which the resources of the field of operations may be depended upon.

The resources of the field of operations may, in general, be utilized by:

1. Billeting, which is the system of supplying the soldier with food and quarters together, i.e., causing him to be fed as well as housed by the inhabitants on whom he is billeted. It depends, in the first place, on the possibility of quartering troops on the country; and, in the second place, on how far it is possible for the inhabitants to provide them with food. The soldier, at the end of the day's march, finds in this case his meal ready cooked and prepared; or, at any rate, has to trouble himself very little with preparing it. Consequently, this system should, when possible, be preferred to others. But in a great many cases it is impracticable from the scarcity of provisions in the district, and must be supplemented by other means. The more troops are concentrated, the less practicable does it become. It is unpopular in the United States probably largely because of the attitude assumed toward it by Article III, Amendments to the Constitution.
2. Contributions in money from towns, etc.
3. Requisitions made and collected by and with the assistance of the local civil authorities.
4. Foraging, which is the forcible taking and distribution of supplies made directly by the military. It is liable to abuse and tends to promote thieving, robbing, and the baser crimes. It destroys discipline, scatters the command, and makes it accordingly inefficient and difficult to control.

The supply officer should in this connection with the four above named methods of supply, assume in all of his estimates: that living on the country does not necessarily mean a saving of supplies. For example, according to the official report of the Base Commissary during Sherman's March to the Sea, when his entire army is generally supposed to have lived off the country, there were issued, or forwarded for issue, from two to three rations per man per day for the entire expedition. This is only one of many similar instances which have been recorded in modern warfare.

While many resources may be utilized (grain, etc., planted) in the field of operations, as is being done in Europe during the present war, it must be borne in mind that the supply problem is much more extensive and complicated today than it was in the time of Caesar or Alexander; and that the greater portion of the supplies and equipment used by the army in the field cannot now, as in the earlier days, be obtained or manufactured in the zone of operations but must, because of their complicated nature, be furnished the army from its field base.

THE RATION

From the foregoing it is safe to assume that, in general, the officer charged with the supply of the rations for troops will have to consider:

1. Components of the ration.
2. Daily consumption and number of days reserve required.
3. When and where required.
4. Where to be obtained and how delivered.
5. How replenished.

Having duly considered these five points, to be prepared at all times to supply the army with what it needs.

Its components are roughly three (3) pounds per man per day.

Beef, 20 oz.; or bacon, 12 oz.
Flour, 18 oz.; or equivalent.
Beans, rice, or hominy.
Potatoes, onions, or tomatoes, 16 oz.
Jam, or dried fruit.
Coffee, or tea.
Sugar, salt, and pepper.

Handling the ration is always difficult and particularly so for untrained men and, in this connection, it is believed that field ranges or soup wagons are superior to the individual cooking in vogue in the United States Army. The latter is a waste of time, food, fuel, and temper, and its results as to sickness and inefficiency are most marked and disastrous.

In concluding this phase of the supply problem, remember that the supply of all stores must not be calculated in pounds and ounces. Estimates must be most liberal.

Two or three times the amount actually necessary should be provided to prevent shortage, consequent suffering, and disaster.

THE SUPPLY OFFICER

An efficient supply officer must have a clear head, be active, well informed, and able to adapt himself and his work to any and all conditions. He cannot work in a groove, but must be resourceful and original.

PEACE TRAINING OF SUPPLY OFFICERS

DISADVANTAGES

The proper supply of the combatants will always depend on the capacity of the officer who is intrusted with providing for them, and on the ability and energy with which his subordinates carry out his instructions.

The piece training which our supply officers receive is not of itself sufficient to prepare them for the performance of the duties they will have to perform in the field. How can men who for years have had no other occupation than to supervise the routine details connected with the supply of a department or large garrison, in a country rich in means, abounding in mercantile firms, general providers, and contractors, and where money can purchase anything within reach of possibility, suddenly develop those qualities which are essential when thousands of men and animals have to be fed in war abroad? As a German officer says,

> To supply troops in time of peace is child's play. The difficulty lies in handing them their provisions in the field.

The supply officers in the field are heavily handicapped by carrying into active service too much of the methodical system followed in garrison. Having to render accurate accounts, notwithstanding the abnormal circumstance of war, hangs like a sword of Damocles over their heads. It may appear wholly opposed to all administrative doctrine to say that accounting for every item of issue is a matter of very inferior consequence in war, nevertheless it is so, and should never be made to usurp a prominent place. The efforts of the supply officer should be primarily directed to purchasing, requisitioning, drawing supplies from the rear, and seeing that the food reaches the troops at the proper time and place. Attention to purely office work can only divert his mind from the most revelant parts of his duties.

It was recently officially stated by the British War Office that many of their reverses in the early part of the war in Belgium and Northern France could be directly attributed to the failure or inability of their supply officers to break away from the routine of peace training.

Finally, the efficient supply officer will remember that in time of war every moment is precious. That to hesitate before acting is a fault; that to ask for instructions, or to wait for orders for supplying the troops, might and probably would be both criminal and fatal.

When the crisis comes and the crucial test of the supply officer is made, the one great and only important question that he must answer correctly is not just how and when and by what authority did he do this or that but could he and did he whenever and wherever called upon "deliver the goods"?

If he procured and furnished *what* was needed *when* it was needed and *where* it was needed, he solved the supply problem assigned to him.

REFERENCES

Army Regulations.
Transport Regulations.
Supply Q. M. C. Manuals.
Circulars, Specifications, etc.
Contracts, etc.
Field Service Regulations.
Duties of the General Staff. Von Schellendorff.
Lines of Communication in War. Furse.
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Supplying Armies in the Field and How to Feed an Army. Sharpe.
Report of a Commissary of Subsistence. Symonds.
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Mess Officer's Assistant. Holbrook.
Mess Sergeant's Handbook. Holbrook.
The Army Baker. Holbrook.
Handling the Straight Army Ration and Baking Bread. Holbrook.

A SET-FORWARD RULER

By Captain CLIFFORD JONES, Coast Artillery Corps, U. S. Army

Description

The ruler consists essentially of a series of right angle triangles having their perpendicular sides (lying along *F G*) common, and their bases (lying along a line parallel to *E D* and passing through *G*) differing from each other in length by a fixed increment.

These triangles are cut by two lines parallel to the base; one defined by the edge of the ruler *E D*, at a distance of thirty seconds from the common apex (0.04 inch = 1 second); the other traced by the pointer *C* as the slide *B* is moved along the ruler.

It is evident, that for any particular triangle if we assume the distance from *F* along the edge to the intersection with the oblique side as the travel during 30 seconds, and having set *C* at a distance from line *E D* equal to the time of flight and moved *B* so that *C* touches the oblique side of the triangle, that the distance from *F* to the graduated edge of *B* will be the travel during the observing interval plus the time of flight.

The sliding T-square *B* has its blade graduated with a time-of-flight scale marked in ranges, the zero being on the 30-second line *E D*, scale same as above (0.04 inch = 1 second).

Operation

Set the pointer on slide to approximate range.

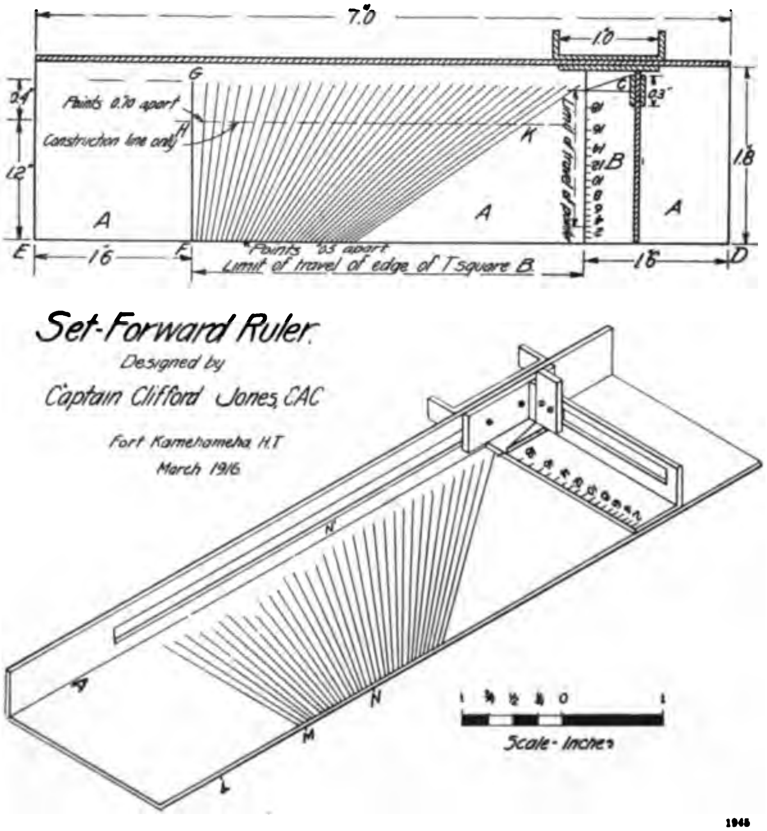
Lay ruler on course with foot of vertical line *F G* on either of the last two plotted points; note radiating line nearest the other of these two points.

Set pointer of slide, by moving the slide, on this line.

Now place ruler on course with foot of vertical line *F G* (or the edge of the T-square) on last plotted point, and mark the set-forward point by the edge of the T-square slide (or at foot of line *F G*). This is a prediction of 30 seconds plus time of flight.

REMARKS

The details of construction are shown on accompanying sketches, the cost is about five dollars.



With the exception of the time-of-flight scale, the ruler is universal up to a time of flight of forty seconds.

Several batteries in the Coast Defenses of Oahu have used this device one or two years, and in all cases it has given satisfaction.

A TIME-RANGE BOARD

By First Lieutenant OSCAR KRUPP, Coast Artillery Corps
U. S. Army

The essential features of this board are:

a. The time-range track of the course of the target is plotted with actual ranges and short observing intervals.

b. The corrected set-forward ranges are obtained from this time-range track.

The advantages claimed for it are:

a. It decreases without any effort the time required for obtaining data necessary to open fire to less than one-third the time often taken with the present system.

b. It makes it possible to successfully track a fast moving target on an irregular course.

c. It can be easily operated in the plotting room and under the supervision of the range officer.

DESCRIPTION

Referring to Figs. 1 and 2, the board can be of any convenient size. A working model has been constructed of slate, on which were graduated the necessary lines. Instead of slate, however, a wooden board could be used with tracing cloth over crosssection brown print. Each five hundred- and thousand-yard line should be made heavy to aid the eye in quickly locating the point corresponding to the actual range.

The top edge of the board is parallel to the range lines and graduated to every five seconds. Sliding along this edge is a T-square with a movable pointer and a sliding ruler. The left edge of this ruler is graduated to read corrected ranges; the right edge is graduated to read range corrections. The ruler should be made long enough to allow for any correction that may be applied. The movable pointer is used to indicate the position of the T-square on the time-interval scale at any time and is kept set to the time of flight (in yards) on the range-time-of-flight scale, which can be moved so as to allow for any adopted predicting interval.

A small straight edge, or plotting ruler, is used to plot the track of the target. The actual plotting may not be necessary though as the corrected range to be sent to the guns is read at the intersection of the plotting ruler and the corrected range scale. For targets going at moderate speeds, the track can be projected ahead with an accuracy within ten yards.

OPERATION

Having decided upon the observing interval to be used, say 10 or 15 seconds, we regulate the time-interval bell accordingly. The base-end readings are transmitted to the plotting room, and are set by the arm setters as usual except that the arms are not removed from the course of the target after each setting. The actual gun range is read each time and this is plotted on the time-range board.

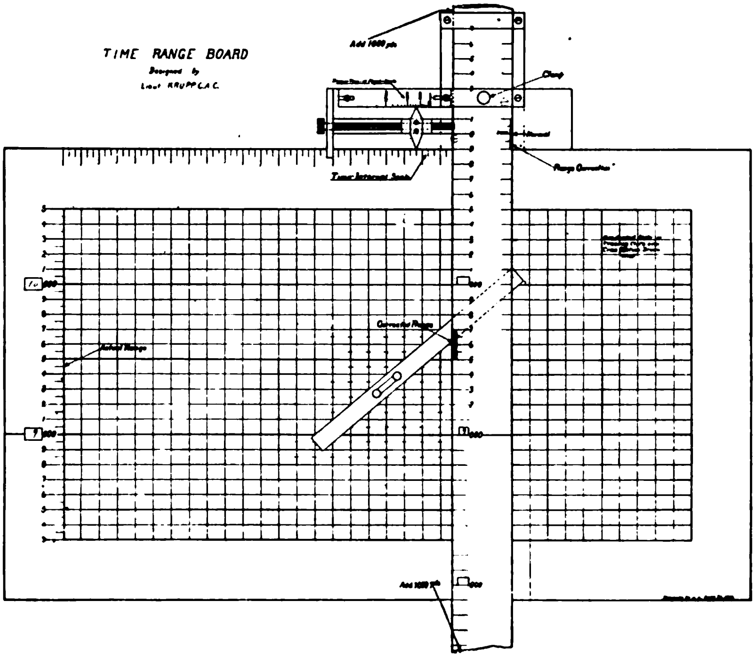


FIG. 1. 1946

The operations of the time-range board are as follows: Plot first actual range received from the plotting board. Mark the thousand digits on the actual and corrected range scales, making the normal of the corrected range scale and the normal of the board the same. Set the movable pointer at the range. Set the range correction to the reference number received from the range board. The present range-board operator makes corrections as usual, but instead of obtaining the corrected range he reads the range correction reference number. Move the T-square so that the lower end of the movable pointer is directly over the second or any subsequent actual range. Repeat operation as often as data is received. Align the plotting ruler along actual range points, projecting the end under the T-square. At any time, or interval desired, read the corrected range on the corrected range scale and then advance the T-square to the right to its new position. The T-square can be set so as to send the range to the guns every interval, or as desired. Corrected ranges, based on the last observation, can be sent to the guns and be set on the range drum ready to fire in 15 seconds.

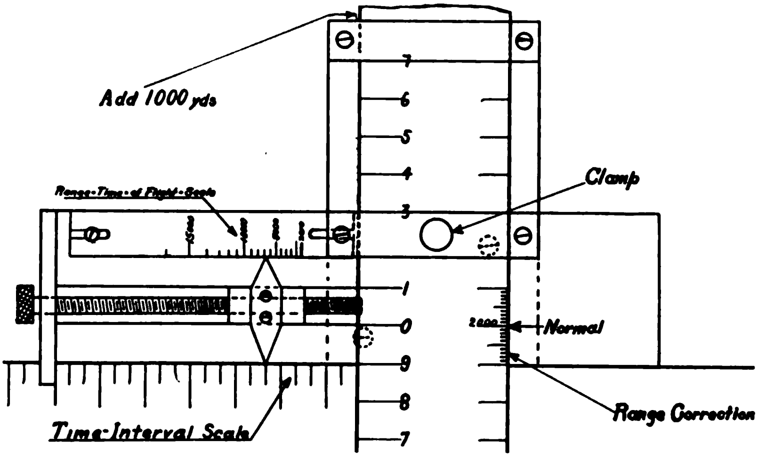


FIG. 2.
UPPER PART OF T-SQUARE ENLARGED

At a recent test a 15-second observing interval was used and the range-time-of-flight scale was set so as to allow also for a predicting interval of 15 seconds. This made it possible to co-ordinate data without the use of a stop watch, and the corrected range based on the last observation was set on the range drum in time to fire on the following bell. The telephone headset at the emplacement was worn by the range setter who was thus in direct communication with the plotting room.

Range corrections were applied to the corrected range ruler of the time-range board by using a range reference number. A pencil index and a 2000 normal were marked on the range ruler of the Pratt range board. Corrections for wind, tide, atmosphere, and muzzle velocity were made as usual.

The observed points were plotted on the plotting board every 15 seconds. The actual gun range of these points was used as a basis for the time-range track. The actual plotting of the time-range track required but a few seconds at the most since the plotting ruler gave the corrected range at any time, it being unnecessary to project the course ahead by dotted lines.

The only work required of the time-range board operator was to continue the track of actual gun ranges. Another person with a headset read the corrected ranges directly to the range setter. This man also set the T-square of the time-range board for the next bell immediately after reading the last corrected range, and set the range-time-of-flight scale whenever it was necessary.

Corrected range data for opening fire was sent to the guns in 30 seconds after the first observation was taken, this time being dependent upon the first range correction. Consequently, under usual conditions the first shot could have been fired on the 3rd bell or at the latest on the 4th bell, or 45 seconds after the first observation, provided of course the guns had been loaded at this time.

NOTES ON THE TIME-RANGE BOARD DESIGNED BY LIEUT. KRUPP, C. A. C.

By Colonel WILLIAM G. HAAN, Captain JAMES P. ROBINSON, and
First Lieutenant ROBERT D. BROWN, C. A. C., U. S. Army

The mechanical device for range correction involves the principle of the Whistler-Hearn plotting board, making correction upon the last observed range instead of the range of the predicted point; it is, therefore, a source of small errors (probably negligible).

The range-time-of-flight scale makes for speed and accuracy; it is very simple and, if properly constructed mechanically, the operation can be performed very quickly.

The mechanical features of the board for use indoors can be made to work satisfactorily. It is suggested that the T-square be made to move by a worm gear with crank at top of right edge of board. It is also suggested that, in addition to the range correction scale, an arbitrary correction scale be put on which will move the range arm together with the range correction scale so that at any time an arbitrary range correction can be made without disturbing the continuity of range corrections received from the range correction board. It is thought that this can be easily done, by mounting this additional scale either in connection with the range correction scale or separately from it.

The radical departure from the present method is that the board is to be used for predicting range to set-forward point, thereby reducing the work on the plotting board and permitting a smaller observing interval. This will reduce the time between the last observation and instant of splash.

The demands upon the skill and judgment of the plotter are greatly reduced, since he is required only to plot the actual range and read it from gun arm; an operation which can be done in a much reduced time—a very desirable result.

It eliminates the uncertainties and annoyances of stop watches, as with this board they are not required. It also reduces the personnel as follows:

a. Eliminates set-forward drum and operator.

b. Where 4 men are now required with time-range board used at the guns, or 2 men if used in plotting room, this board requires but 1 man.

A valuable feature is the reduction by more than one-half of the time required in getting data to fire the first shot.

The probable errors in range, due to prediction on the time-range board instead of the plotting board, should be no greater for the same period of prediction, and should be less if by the use of this board that period can be reduced. The assumption frequently made that ships of a fleet will continue on a curved course is not justified. Fleets are, and of necessity must be, maneuvered on lines of bearing, and changes in course are made only to get a new line of bearing ordered on which new course they then continue. This feature has been fully discussed with naval officers who insist that all their tactics necessarily require ships to run on courses and not in curves. The direction, of course, is frequently changed, but the order is given to change so many degrees to the given bearing of the new course. After the change has been made, the new course is run in a right line. It is, therefore, erroneous to assume on the plotting board that the target will continue in a curve if the last several observations indicate a curved course. It means that the ships are turning to again continue in a straight course.

A careful study of actual courses run by the battleships *Rhode Island* and *Georgia*, diagrams of which have been kindly furnished by the Navy, shows that a battle-cruiser going at 24-knot speed, and without changing its speed, but changing its course only, can be away from the set-forward points for the various predicting intervals, distances as shown in the following table:

(Speed of ship—24 knots)

	Time from observation to set-forward point	Distance of target from set-forward point	First order of differences
1	15 seconds	40 yards	40
2	30 "	185 "	145
3	45 "	410 "	225
4	60 "	700 "	290
5	75 "	1040 "	340

This table shows the extreme importance of reducing the time between the instant of last observation and the instant of splash. It is evident that if the predicting interval can be reduced, it will tend to shorten the period between the instant of observation and the instant of splash, and, therefore, will eliminate that part of this period in which, as is readily seen from the above table, the possible rate of moving away from the set-forward point is greatest.

This board is especially adapted, and will be seen in its most favorable light, when its use is considered in connection with the long self-contained base range-finder. Under such conditions of range finding and prediction, there would be made possible extremely short intervals of observation and prediction, and, consequently, as deduced in the previous paragraph, a reduction of probable errors.

After careful study, the writers are of the opinion that this device should have serious consideration by those who are responsible for seeing that our Coast Artillery equipment keeps abreast with improvements in other lines.

TIME-RANGE BOARD FOR GUNS

By Captain G. A. WILDRICK, Coast Artillery Corps, U. S. Army

This time-range board is designed to satisfy the fundamental plotting principles embodied in *Drill Regulations for Coast Artillery, United States Army, 1914.* Among the reasons for proposing the use of this board are the following: (1) convenience of operation; (2) probable increase in the accuracy of the data applied on the range scale of the gun; (3) ease and cheapness of construction.

In explaining the operation of the board while in use at batteries, some of the more or less novel features required an explanation as to the reasons underlying the design. For the benefit of any who may be interested in this device, experience influences the writer to put down a prefatory discussion touching upon the so-called "1909 system," and why the board as arranged for the 1914 system is believed to be superior to its original adaptation to the 1909 methods. As adapted to the 1909 system, it was rejected three or four years ago. In its present form it is believed that it possesses any convenience claimed for the 1909 system, and that it takes advantage of the more accurate gunnery methods prescribed by present drill regulations.

SOME ASPECTS OF THE 1909 SYSTEM

In this system the corrected range of the set-forward point for the next bell was not plotted, but was computed from the range travel of the target during the preceding observing interval.

EXAMPLE I

(See Fig. 1)

This figure was determined on a plotting board. The lines of direction are shown. Assume: a 12-inch gun, capped projectile, range table conditions, the simple condition of a target on a straight course, a 15-second observing interval, 20 seconds time of flight, and a target traveling at about 20 miles per hour.

On bell *1* the range was 11,100 yards; on bell *2*, 11,000. Range travel, minus 100 yards in 15 seconds. If we fire on bell *3*, the range of the set-forward point *a* will be computed to be

$$11{,}000-100-100\times\frac{20}{15}=10{,}770 \text{ (nearest 10 yards)}$$

The range of *a* is 10,780. The error is −10 yards, which will have practically no effect on the probability of hitting.

EXAMPLE II

(See Fig. 1)

Take another case. Assume that the range correction applied on the gun arm was +300 when the corrected range of 11,400 yards to point *1* was read. If a new range correction of +280 were applied before the next bell, a corrected range of 11,280 to point *2* would be determined. The corrected range of the set-forward point for firing at time *3* would be computed to be

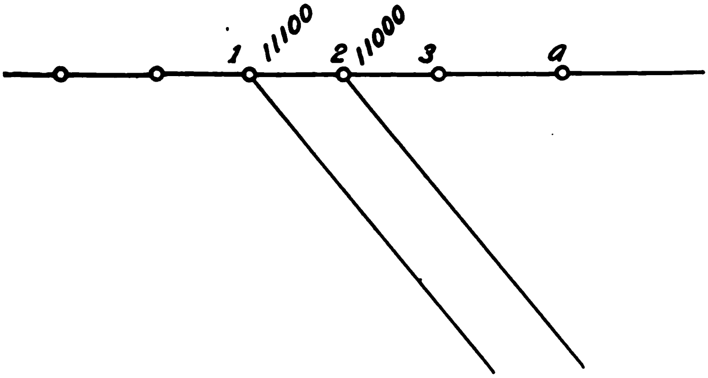


FIG. 1. 1948

$$11{,}280-120-120\times\frac{20}{15}=11{,}000$$

We have seen that the range to *a* is 10,780. Adding 280, we have 11,060 as the true corrected range of *a*. The error is −60 and will affect the probability of hitting.

To get satisfactory results with the 1909 system, even under ideal conditions as illustrated, it is necessary to prevent the entrance of a spurious range travel such as observed above. his could be done as follows: After every point is plotted, d the range to the previous plotted point, then that to the one just plotted, using the latest range correction on the gun arm for both readings. This will require clearing the arms and reading two ranges for use on the predicting device.

EXAMPLE III

(See Fig. 2)

Accept again a target on a straight course, but with base end readings or arm settings such as to form a ragged track.

Points *1*, *2*, and *3* are plotted points. The line *MN* is the track of the target. Assume the general conditions of Example 1.

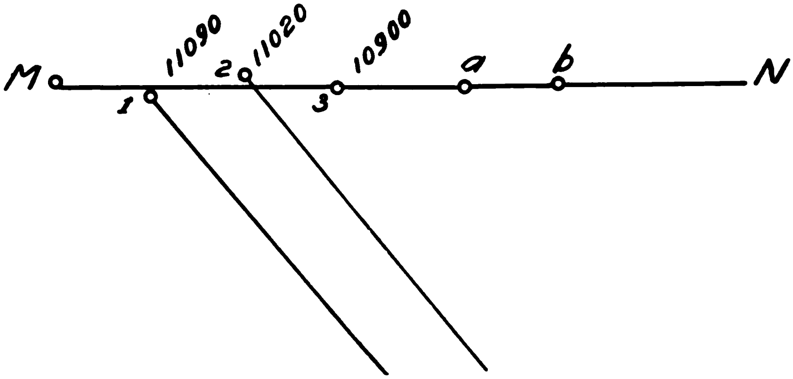


FIG. 2. 1949

If a prediction is computed on range travel between points *1* and *2*, the corrected range of the set-forward point *a* for use at time *3* will be computed to be

$$11{,}020-70-70\times\frac{20}{15}=10{,}860$$

and the true range to *a* is 10,780. The error is about +80 yards. Similarly, between points *2* and *3* we get a range travel of -120 yards, from which the range of the set-forward point *b* will be computed to be

$$10{,}900-120-120\times\frac{20}{15}=10{,}620$$

and the true range to *b* is 10,690, an error of -70 yards.

If we credit a 12-inch gun, using single section charges, with an accuracy equal to the 10-inch guns of Battery Eustis, Fort Monroe, Va., we will observe that an error of -70 yards will reduce the probability of hitting at this range from about 34 per cent to 28 per cent. (See Chart D, page 53, JOURNAL

U. S. ARTILLERY, Jan.-Feb., 1916.) And if this error is accompanied by a spurious range travel of −20, we would have the following condition:

Corrected range to *2*, 11,020+300 = 11,320
Corrected range to *3*, 10,900+280 = 11,180

Range travel = −140

The corrected range to the set-forward point *b*, to be applied at time *4*, would be computed to be

$$11{,}180-140-140\times\frac{20}{15}=10{,}850$$

The true corrected range to *b* is 10,690+280 = 10,970.

The error is −120 yards and may reduce the probability of hitting from about 34 per cent to 19 per cent.

Not only may these errors occur, but they are to be expected.

THE 1914 AND PROPOSED SYSTEMS

Ragged tracks even by use of a horizontal base have been encountered repeatedly by the writer during seven years' service at major caliber batteries in drill and target practice. It is believed that the plotted point itself is open to suspicion, and that the proper system is the one that demands that the plotter have the arms cleared so that he can study the course as plotted and make his estimate of the *direction* of the course. This, it is believed, is the fundamental of the 1914 system.

When we consider tracking by auxiliary, vertical, or self-contained base, the character of the data supplied to the plotting board will be such as to show distinctly the advantage of the 1914 system. The system followed should permit of application of the data on the plotting board, whatever base is used for securing the data. To use one system for horizontal base, and another for tracking with a self-contained base instrument, is needlessly complex and impracticable.

Another feature of the 1909 system was the absence of any proper means of interpolation between the corrected ranges furnished after each bell, except by guess work. This was done either by moving the slide on the old time-range board at the emplacements, or by creeping at the range drum the estimated rate of range change. A serious objection to creeping is that the application of a correction from instrumental observation of fire will cause a jump in the data. The tendency of range setters is to smooth out such jumps or to disregard them as erroneous. Since adjustment of fire requires as a basis that the system respond promptly to corrections made, it is essential to fire discipline that range setters be required to set what ranges are indicated to them, and that their responsibility be ended there.

No material advantage is seen for the 15-second observing interval as compared with the 30-second, excepting when the target changes direction. The battery can be put in action about as quickly with one interval as another. Observations can be secured as frequently as desired by "Ready" and "Take" sent to the observers. After having observed numerous delays in getting a battery in action in target practice "waiting for the course to get smoothed out," the writer believes that for all practical purposes the one interval is as good as the other, and that oftentimes the fire control section is not trained up to take full advantage of the rapidity offered by the system we now have. It is believed that we should not be concerned so much with the *observing* interval as with the *predicting* interval. Even by the 1909 system the predicting

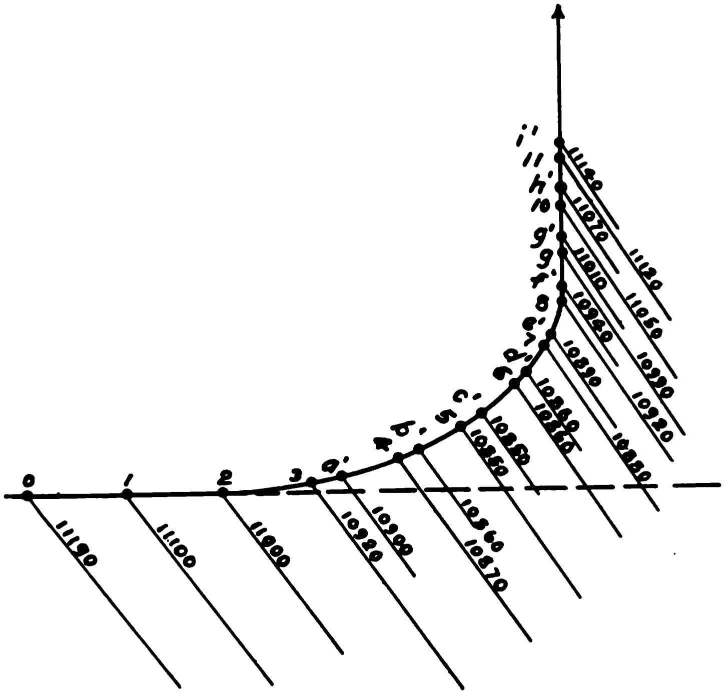


FIG. 3. 1960

interval must run up to about 55 seconds with the long pointed projectile and increased elevations. The result is that the determination of the range setting at any instant must be made between predictions sometimes 50 seconds ahead; and if the target changes course, the range settings will be in error until the time runs out and the corrected ranges computed approach again the true corrected range of the target. In fact, it is in this particular that both systems may be improved upon. Fig. 3 will illustrate the issue raised for the 1909 system, and Fig. 4 shows that for the 1914 and for the proposed system. In Fig. 3 the assumption is made for comparison that the plotting is theoretically correct on the data furnished. In Fig. 4, *a*, *c*, *e*, *g*, and *i* are set-forward points located by present methods; *v*, *w*, *x*, and *y* are set-forward points located by the proposed system.

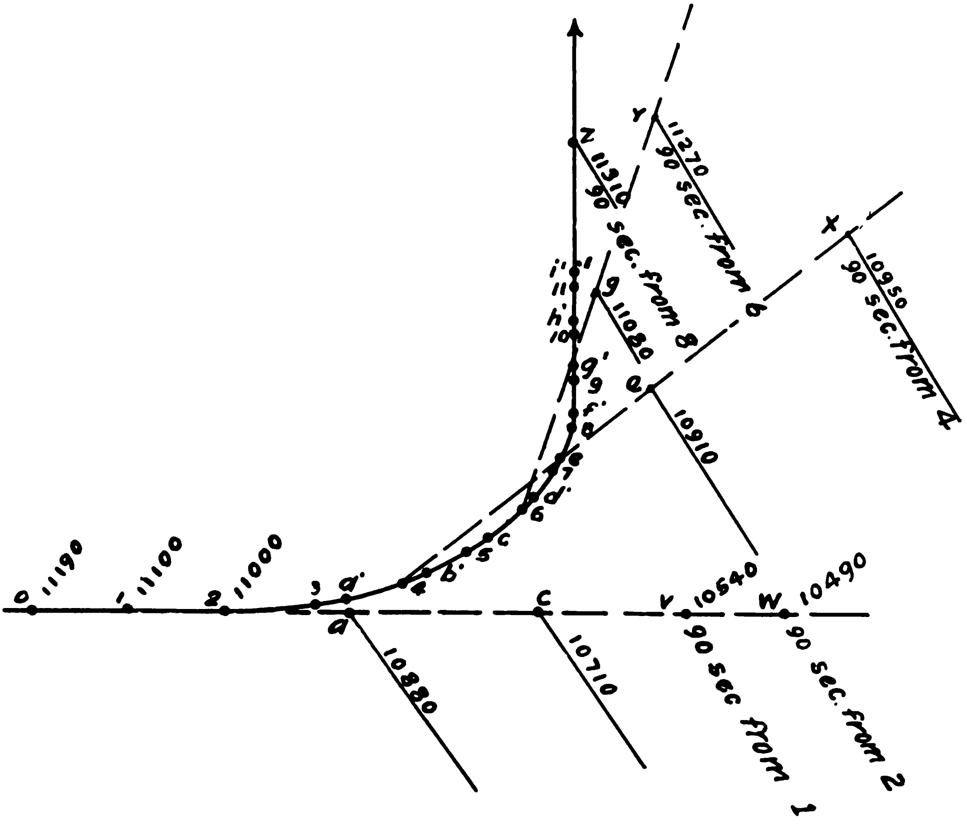


FIG. 4.

The track in Fig. 3 is reproduced in Fig. 4. It credits the ship with an advance of about 500 yards, and a tactical diameter of about 460 yards; with full speed of about 20 miles per hour during the first two intervals after commencing the turn, ¾ speed from *4* to *6*, and ½ speed from *6* to *11*. The figure is laid out to a scale of 1 inch = 300 yards, and illustrates one of the hardest conditions for a plotting system to meet. It was placed upon the plotting board at random with the idea of seeing what the data would indicate.

In the plotting of the set-forward points, the writer endeavored to make an estimation of the direction of the course of the target as it might be done by the average plotter. They were located somewhat in error, due: (1) to the continued turning of the target, and (2) to the decreasing speed of the target during the turn. Therefore, in the predictions in Fig. 5, the 1909 system is credited with perfect operation, against only an average solution for the others. The 1909 system appears in the most favorable light possible to give it under the conditions.

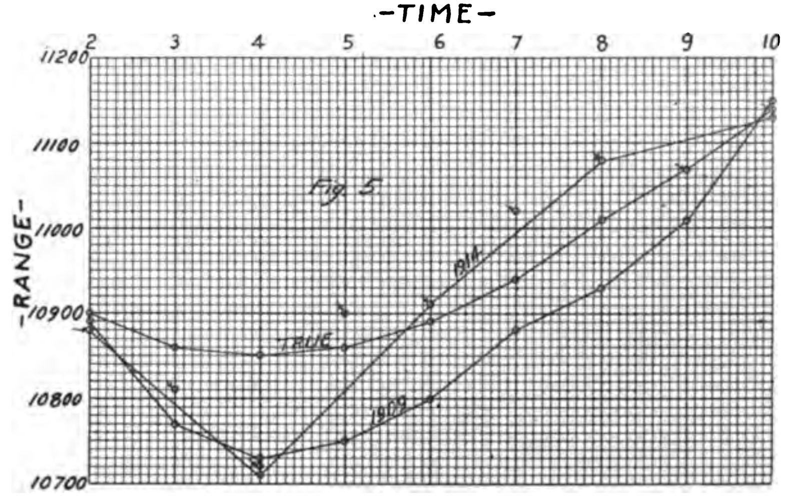


FIG. 5. 1952

The curvature of the course is quite as sharp as may be expected from any dreadnought target. If so desired, any one system may be made to appear in an especially favorable light by a judicious selection of a track. Also, each system may excel under certain conditions. The question is what one promises the best all around solution for gunnery purposes against battleship targets rather than in target practice.

In the proposed system (Fig. 4) the interpolation for the range at any instant will be made between the ranges of *1* and *v*, *2* and *w*, *4* and *x*, *6* and *y*. The following table shows the comparative data secured, and this is shown graphically in Fig. 5. It is to be noted that the interpolation of ranges is made between ranges of set-forward points predicted 35 seconds ahead in the 1909 system, and 50 seconds ahead in that of 1914. For the proposed system the set-forward range determined for any time (in this case on each bell) is shown by a circle and an arrow. The arrow indicates when the range thus secured coincides with that by another system. A 30-second observing interval was assumed, set-forward points being plotted as shown in Fig. 4. It is interesting to note in passing that where the center of impact has been adjusted to the center of a target and the target makes a turn, the shots will probably begin falling short if the target turns away from the battery, or over if the course changes in toward the battery. In neither case is a correction of fire justified. The fire will be adjusted as soon as the set-forward points again approximate the track.

Time of Firing	Set-forward Ranges Determined by Systems			
	True Range	1909	1914	Proposed
2	10,900	10,890	10,880	10,880
3	10,860	10,770	---	10,810
4	10,850	10,730	10,710	10,720
5	10,860	10,750	---	10,900
6	10,890	10,800	10,910	10,910
7	10,940	10,880	---	11,020
8	11,010	10,930	11,080	11,080
9	11,070	10,010	---	11,070
10	11,140	11,150	11,130	11,140

The suggestion made is this: Instead of interpolating between corrected ranges of set-forward points, *make the interpolation between the actual range of the plotted point and the actual range of a set-forward point plotted at any convenient time forward along the estimated course of the target.* That is, start a fresh prediction on every bell. Locate the plotted point (adjusting it if necessary for smoothness) and locate a set-forward point along the estimated course of the target. Read the uncorrected range to the set-forward point and that to the plotted point, and interpolate between the two. The plotted point is the best information at hand. By this plan we have one foot on firm ground. This is the essential idea in the proposed time-range board. By it the *predicting* interval is reduced to the minimum. If it is desired to fire the gun at any given time, the prediction for the shot will be for a time equal to the time of flight plus the time elapsed since the last bell. The predicting interval cannot be reduced below this.

PROPOSED TIME-RANGE BOARD

(See Figs. 6, 7, and 8)

The operation of the system is as follows:

After two points are plotted, the plotter estimates the direction of the course of the target. On this course he locates a set-forward point 90 seconds ahead of the plotted point.

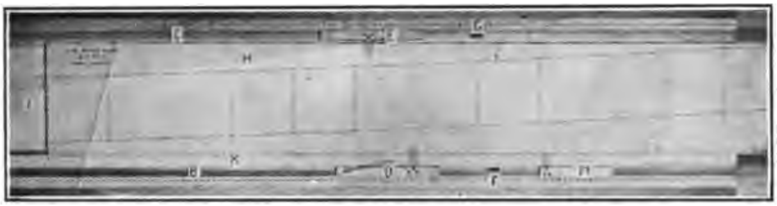


FIG. 6. 1953

He reads the range of this point and of the plotted point. The operator of the time-range board brings the index on *E* (Fig. 8) to the set-forward range on scale *G;* and the index on *D* to the range of the plotted point on *F*. Ten seconds after the bell he reads the set-forward range under the string on the lowest curve on the movable platen *H*. He sends a range every 5 seconds by reading at the intersection of the elastic string and each succeeding curve until new data comes from the plotting board, when the process is repeated. Each curve is marked with the time after the bell that a reading should be taken therefrom. The operator times his readings by a stop watch.

The platen *H* slides with reference to the fixed range scales *F* and *G*. When No. 4 has worked out a new range correction reference number on the range board, he moves the platen *H* until the reference number on the platen is under the fiducial edge of the T-square *M*. Normally this edge is coincident with the "1000" line found on the lower right hand side of board and with the "2000" range correction reference number above on H.

Correction from instrumental observation of fire is effected by moving [illegible] the desired amount and resetting the reference number under its edge.

It will be noted that the range travel is based on uncorrected ranges, and that the prediction for travel during time of flight uses the time of flight of the corrected range.

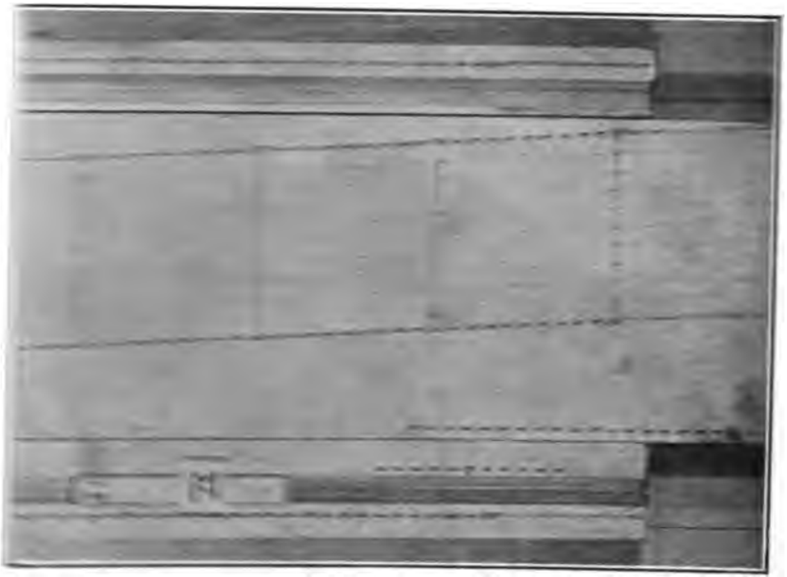


FIG. 7. 1964

The lowest curve on *H* is plotted as follows: *H* is covered with [illegible] cross-section paper. Assume that the left edge of the platen is 1000 yards. Lay off horizontally succeeding ranges by increments of 1000 yards, to a scale of 1 inch = 200 yards.

The vertical scale is taken at 1 inch = 5 seconds. The lower edge of the platen is the time reference line and represents zero time after the bell. Then, to plot the 10-second reading curve, locate a point at every thousand yards at a distance to scale vertically above the reference line equal to 10 seconds + the time of flight for the range. Connect these points by a smooth curve. The 15-second, 20-second, * * * 60-second reading curves are plotted parallel to the 10-second curve at vertical intervals of 5 seconds. Fill in the intermediate ranges on the platen.

The subcaliber reading scales are similarly plotted on the reverse face of the platen.

The reason for suspending the elastic string as shown is to allow for the time required to set the range on the gun, as determined by trial. By lowering the points of attachment to scale, the range read at any time is set forward to include the time required to set the data.

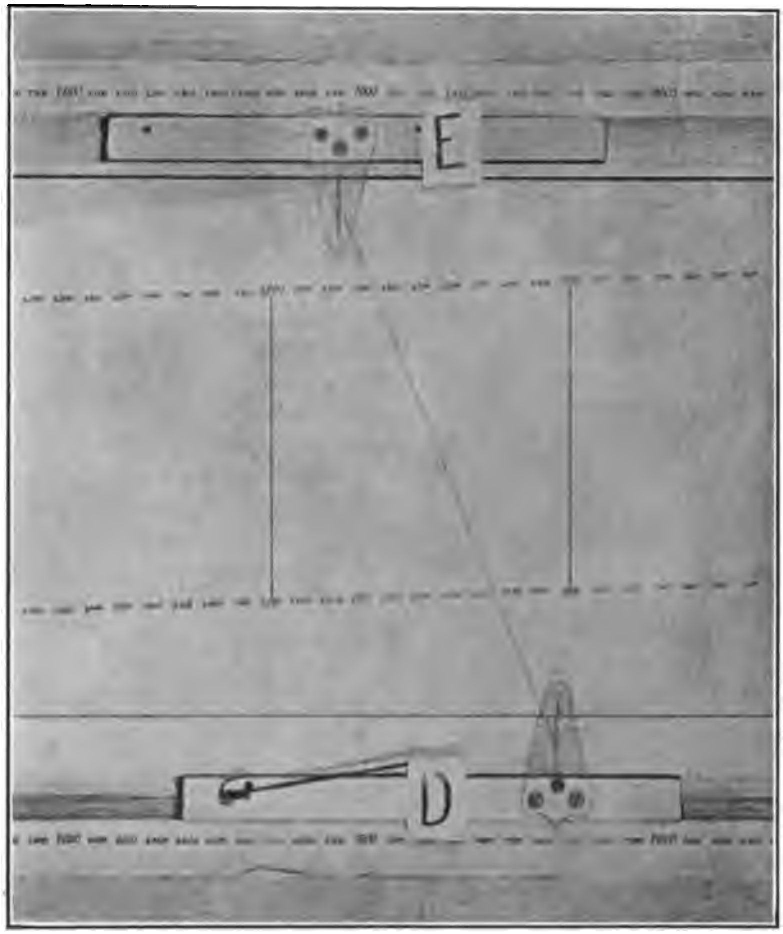


FIG. 8. 1966

Assuming that at 23 seconds after the bell either a new range correction or a correction of fire is applied. At 25 seconds the range sent to the guns will indicate a jump in the data. The range setter must be held responsible that the range is set as indicated. Creeping should be prohibited.

If at 15 seconds after the bell the plotter is informed that the target is turning hard to port, he locates another set-forward point in the new estimated direction, reads the range thereto, and it is set on scale *G*. The next corrected range as read on the 20- or 25-second curve will cause another jump in the data. The range setter must be held responsible that the range is set as indicated to him. The range scale on the gun carriage is no place for smoothing out data or predicting.

If a reading is lost by whatever base is in use, the plotter estimates the position of the plotted point, locates the set-forward point 90 seconds ahead, and the work proceeds as normally. All predictions are made on the plotting board. This time-range board is merely an interpolating device.

The predicting interval being fixed at 90 seconds, the plotter determines the set-forward point without needing proportional dividers, or a set-forward ruler, etc. Allowance for range travel during the time of flight, is made in the plotting of the reading curves on the platen.

A fixed predicting interval is recommended so as to allow for such an extreme condition as 34 (time of flight) + 30 (observing interval) + 24 seconds to get the new data applied after the next bell. If a 15-second observing interval were used the fixed predicting interval could be taken at 60 seconds. *On each bell the prediction starts over again from the plotted point, and only that portion of the whole 90 seconds is used as may be required until the new data is supplied from the plotting board after the next bell.*

In Case II it is recommended that the angular travel be determined elsewhere than on the plotting board.

In Case III the corrected range for the next bell is read on the 30-second reading curve. The corrected azimuth of the set-forward point for the next bell may be determined by bringing the gun arm to a point 30 seconds ahead of the last plotted point—the correction for wind, drift, and angular travel of the target having been applied to the gun arm. Or the azimuth solution may be worked out elsewhere.

In designing the board the writer has endeavored:

1. To produce a device which will illustrate on its face the gunnery principles involved.
2. To produce a time-range board that will be elastic and convenient in its operation, so that a new time-range relation can be established and picked up promptly either on new

information to the plotter as to the movement of the target, or on the application of a new range correction: to the end that the system will have the latest and best range data possible to obtain, and that the range settings on the guns will respond promptly.

3. To produce an inexpensive board easy to construct, and without cams, gears, screw motions, etc.

4. To lighten the work of the plotter and permit him the maximum time to study the track, estimate the direction that the target will go, and quickly modify the data as the occasion may require.

USE OF HEAVY ARTILLERY ON RAILWAY CARS AND AUTO TRUCKS IN THE EUROPEAN WAR[1]

BY CAPTAIN FRANK T. HINES, COAST ARTILLERY CORPS, U. S. ARMY

This statement of the Chief of Staff in his report of June 30, 1915, is particularly apropos at this time:

> The history of war will show that almost without exception, each great conflict has resulted in the introduction of new and powerful weapons and devices for offense and defense. Initial advantages of immense import have been gained by a belligerent who has developed some innovation against which no immediate defense was adequate. The innovation of yesterday becomes the necessity of tomorrow. The present gigantic conflict waging in Europe is too near perspective and too obscure in detail to grasp as yet all its manifold lessons, but one of the great outstanding features is the use of large calibered mobile artillery.

Prior to the present war two distinctive opinions prevailed as to the character of mobile artillery and its use. The French believed that their 75-mm. (3-inch) field piece was perfection itself and they were the foremost exponents of the theory that a large volume of fire from the field pieces of this caliber could fairly smother the fire of pieces of larger caliber, and cause their fire to become ineffective; and no one questioned the effect of this type of gun against troops of all arms.

The Germans and Austrians agreed to the same opinion, so far as the use of a small caliber field piece against personnel, but quietly went to work, as far back as 1908, with the development of heavy field and siege artillery which they considered essential to the reduction of field fortifications and for counter attack against the more numerous but lighter field pieces.

England and Russia were not as well off in regard to heavy mobile artillery as France; and Italy was in the same class.

In general, Germany and Austria were the only European countries that had developed efficient large-caliber mobile artillery at the outbreak of the present war, and little was known at that time to what extent this development had progressed.

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[1] For illustrations of heavy mobile artillery, see recent issues of the JOURNAL U. S. ARTILLERY.

It was not until the world was astounded by the news of the use of a 42-cm. (16.5-inch) siege howitzer, or mortar, and the resulting ruins of Liège, Namur, and Maubeuge, that the fallacy of the French theory was admitted and the urgent necessity of large-caliber mobile artillery became apparent.

Mechanics would have transformed war even if it had not been applied in other fields than that of transportation. Armament has also been benefited. The principal weapons are machines, and they number, now, among them man's greatest conception.

The experiences of the present European war have caused many profound modifications in the theories commonly held before the war broke out, but no factor was perhaps so underestimated as the effect of high explosive shells fired from large guns and howitzers. The successes of the Japanese at Port Arthur had given an inkling of the potentialities of the heavy howitzer against permanent fortifications, but the decisive effect of high explosives against troops in the field in well-concealed intrenchments has come as a complete surprise.

The gunner, and more especially the garrison or coast defense gunner, has come into his own, for this branch of the service has assumed an importance greater probably than it has ever before possessed. It is extremely hard to conceal the position of the trench from an aerial observer; and once their location is notified to the guns and the exact range is obtained, it is not long before the whole length of the trenches will be blown in and entanglements and every form of obstacle, however ingenious, swept away.

As yet, our knowledge of the details and mechanism and the manner of operation of these new engines of war is, for the most part, meager and confused, and in many cases it is difficult to tell whether the pictures published are real or the creation of a very clever artist. Nevertheless, in case of war with a modern power we must expect to be confronted with hostile mortars and howitzers of large caliber and great destructive power in our military operations.

It is believed that a clearer presentation of this subject can be made by giving consideration in order, and taking the subject matter up separately under each of the great nations now at war.

GERMANY

The Germans and Austrians foresaw the controlling effect of heavy mobile field artillery in future warfare, and they prepared accordingly. Their early successes and their present unbroken front are largely due to their possession of numerous heavy howitzers, of which the Allies, for the first year at least, possessed practically none.

Long before the war and at least in 1908, funds (some $2,000,000) were obtained by the German military authorities for a competitive test of various types of heavy ordnance on auto-trucks or the transportation of same by tractors. Exhaustive tests were made in that year and also during 1911, which resulted in the formation of auto-truck companies or batteries of heavy field and siege artillery.

It is now known that the Germans had 42-cm. (16.5-inch) mortars manufactured, no doubt by the Krupps, some time before the war, and considerable confusion has occurred between this German 42-cm. mortar and the Austrian 305-mm., commonly referred to as the "Skoda."

The "Skoda" howitzer was developed by the Austrians before the war broke out, and it is to them that the reduction of the Belgium forts and those at Przemsyl is largely due. They have proved very accurate and their shells have terrific effect both against fortifications and troops in the field. They fire a shell weighing 860 pounds with a muzzle velocity of 1115 f.s., the maximum range being 14,000 yards. They are very mobile and can be mounted in 24 minutes and entirely dismounted and moved away in 40 minutes. This permits them to quickly take up a new position when discovered by hostile air-craft, and also offers little chance of capture. They are transported in sections on tractors at a rate of 12 miles per hour. They are drawn by a Skoda-Daimler car of 100 horse-power, with four driving wheels, and at low speed can go up a 16 per cent grade. These mortars had been in use some time prior to the war and most of the heavy artillery of the Germans at this stage of the war was of the Skoda type and some at least were manufactured by Austria.

From the data available it appears that the recoil of the Skoda mortar is taken up by oil in cylinders, and is returned into battery by compressed air. The piece is set on a portable foundation when the ground is soft. When the foundation [illegible]sed, the piece can be traversed 60 degrees on each side of the median line; without the foundation, a slightly less angle of traverse is possible.

Data available would seem to indicate that the Germans have two very different types of 42-cm. mortars or howitzers: one transported by motor trucks and the other on railway cars; the latter type being more powerful than the former which is fired from its wheeled carriage, while the latter is placed on a concrete base. The cars are run on spur tracks directly on the edge of the emplacement pits. The train contains a derrick car which is used to mount the parts of the mortar and its carriage, as well as to handle ammunition.

It has been reported that it takes 100 men 6 hours to assemble or take down the latest type of these howitzers, and within 36 hours the concrete bases can be installed and the guns put in position and action.

The following description of a 42-cm. howitzer battery will no doubt be of interest:[1]

These notes are the result of an accidental encounter with one of the 42-cm. howitzer batteries while on a visit of inspection to the 6th German Field Army, on the Arras section of the west front, between Oct. 1 and 8, 1915. The battery was first met on the road at Henin-Lietard, near Lens, on October 1, where the officer in charge explained the system of transportation. On October 5 the battery was again inspected by special permission, this time on the road near Pont Maudit when the loaded wagons were uncovered, and a number of the details explained. On October 8 the battery was inspected in a firing position near Estevelles, while bombarding Loos, which had been taken by the English on September 25, during the recent great offense of the Allies.

Method of Transportation

The battery consists of two pieces. Each piece with its carriage and maneuvering appliances is transported on five steel framed carriages with built-up riveted steel wheels. Each carriage is of a special design to suit its load. Each wagon is drawn by a motor tractor to which it is close coupled by a yoke and coupling pin. The whole battery, therefore, comprises ten units, each unit being made up of a wagon and motor. In addition, four other ordinary motor trucks of four or five tons capacity accompany the battery, carrying small parts, supplies, etc. Owing to the size of the units, the battery takes up considerable road space and makes a formidable appearance. When inspected on the road, all wagons were covered with freshly cut boughs, as a screen against aviators, and care was taken, when halted, to stop under the trees bordering Chaussee. The loaded wagons are normally covered closely with paulins, so that nothing can be seen.

The wagons of each piece are numbered and designated as follows:

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[1] From the report of an observer.

No. 1 wagon, the appliance wagon, carries the material required in assembling the howitzer and carriage, and for dismounting same.

The principal item of the load is the four-legged gin and winch with block and tackle. The legs of the gin are hollow steel spars fitted with couplings. The appliance wagon also carries heavy steel anchor pins, snatch blocks, and certain parts of the carriage, such as elevating and traversing gear, loading cranes, etc.

No. 2 wagon, the platform wagon, carries a one-pieced steel-frame, U-shaped platform with two box girder steel rails for hauling the carriage into place on the platform.

No. 3 wagon, the cradle and spade platform wagon, carries the howitzer cradle and a huge spade of special construction, to be described later.

No. 4 wagon, the carriage wagon, is the carriage proper of the piece, the hind wheels of the wagon constituting the carriage wheels as in a field gun, the front wheels of the wagon being used only for road transport and being uncoupled from the trail and replaced by the spade when the piece is mounted for firing.

No. 5 wagon, the howitzer wagon, carries the piece which is supported in the grooved side rails of the wagon by projecting ribs on the side of the howitzer.

Motor Wagons

The motor wagons attached to No. 1 are larger and more powerful than the others, having motors of 60-80 h.p., and being provided with a steel-cable drum slung under the chassis. This drum is driven by the engine and is used for the purpose of hauling the different wagons on and off of the platform. The motor wagons attached to wagons 2, 3, 4, and 5, have engines of 40-50 h.p., and are of different systems and manufacture with the avowed intentions of trying out the different types of motor tractors under service conditions. Among the manufacturers noted are Daimler, Benz, Pedens, and Pohl. All motor tractors are essentially of the same type as developed in Germany for agricultural purposes. They all have cleated rear wheels about 8 feet in diameter, with tires 12 to 14 inches broad. In the Pohl system, the rear wheels have, in addition to the cleats, a system of steel blades operated by an adjustable eccentric on the axle, and working through slits cut at right angles through the steel rim. By proper adjustment of the eccentric, these steel blades can be set to project beyond the surface of the steel rim, and thus afford a better grip on the ground than is possible with the fixed cleats. This arrangement is similar to the feathering arrangement sometimes used on the paddle wheels of steamers, and is stated to give increased adhesion, particularly on soft ground.

All engines on motor tractors are four-cylinder, water cooled, magnetic ignition, of simple but rugged construction. Transmission of power to the rear axle is by chain drive. Steering is effected through the medium of a quadrant and a chain, much the same as is used in heavy road rollers. One make of tractor had but one wheel on the front axle.

Assembling of the Piece and Carriage

For convenience in assembling the piece and carriage in the firing position, the various wagons of the battery are formed in column with the two No. 1 wagons at the head, followed by the two No. 2 wagons, then the two No. 3 wagons, and so no. When travelling on metalled or hard roads, the wagons carrying parts of the carriage and the piece move on their ordinary wheels which have smooth steel rims about 10 inches wide. When moving over soft ground, such as when leaving the road to move into a firing position, caterpiller rims or girdles are fastened to the front and rear wheels of the loaded wagons. These rims consist of twelve segments for the hind wheels, which are some five feet six inches in diameter, and of eight segments for the front wheels which are about three feet six inches in diameter.

The position of the emplacements having been determined, and the caterpiller rims attached, the column is moved by the head to the designated position. Each No. 1 wagon moving to the emplacement of its piece, is followed by the other wagons pertaining to that piece. No. 1 wagons are halted at the emplacements and, after erecting the gins and unloading their loads, are hauled aside. The motor tractors of the No. 1 wagons then take up their position a short distance in front of the emplacement, from which point they can haul the remaining wagons up onto the platforms by means of the cable drums. If the ground does not admit of a straight line pull, the tractors are located at any convenient point and the cable led around a snatch-block to an anchorage.

No. 2 wagon is then hauled under the gin and the platform lifted clear by the gin, after which the wagon is hauled away and the platform lowered to the ground, previously leveled for this purpose. When the ground is firm, no other preparations than the leveling are required. When the ground is soft, various expedients can be employed, either excavating to a firmer foundation, filling in with broken stone, or laying of a grillage of planks. The steel platform is lowered upon the prepared surface, carefully leveled, and oriented in the general direction of the fire.

No. 3 wagon is then hauled onto the platform, using the steel box rails for this purpose, and the spade unloaded and temporarily laid on the ground. The cradle is then hoisted clear and the wagon hauled away, leaving the cradle suspended from the gin. No. 4 wagon is then hauled onto the platform, with caterpiller wheels attached, and approximately centered on the platform. The cradle is then lowered into the carriage, the cradle trunnions resting in the trunnion beds. The front wheels of No. 4 wagon are then uncoupled from the wagon, and removed.

No. 5 wagon is then hauled up, its side rails being brought into line with grooves on the inside of the cradle, and the howitzer pulled off, the machined ribs on the side of the barrel engaging in grooves in the cradle as they leave the grooved side rails of the wagon. The spade is then hauled into position and coupled to the trail of the carriage, the traversing and loading gears assembled, leaving the piece ready for firing. The battery commander stated that under favorable conditions, the battery could be set up for firing in three hours.

THE SPADE

An interesting feature of the mount is the "sporn," or spade, which serves both to check recoil of the carriage and as a traversing rack for changing direction horizontally. It consists, essentially, of a huge segment of a circle of peculiar radial cross section, being built up of steel plates and frames, measuring about 11 feet on the chord. The radial cross section measures about five feet high and six feet broad over all. The upper surface of the spade is in two levels, on the lower of which rests and slides the carriage-trail. In the vertical surface, connecting the two upper levels, lies a rack into which a pinion, fastened to the trail, engages. By operating the hand wheel on the pinion shaft, lateral motion is imparted to the trail. To the lower leg of the spade are bolted six blades, each approximately two feet wide, which engage the ground and check the recoil of the carriage. If needed, a trench can be dug for the lower edge of the spade, and the back of the trench filled with broken stone or gravel well tramped into place to secure better resistance.

THE CATERPILLAR RIM

The caterpillar rim consists of a double row of shoes, the outer shoes being about 22 inches wide by 26 inches long, and 2 inches thick, apparently of solid steel. The inner shoes are flanged so as to engage the wheel rim, and are hinged to the outer shoes at their middle. The slack of the girdle is such that at least two of the shoes lie flat on the ground and for but a small sector of arc three shoes are on the ground. The arrangement, therefore, insures that the weight of the wheels is always distributed to the ground through at least two outer shoes, resulting in such a distribution of weight as to enable the wagons to be hauled over soft ground. In this connection, the battery commander stated that the motor tractors with caterpillar wheels could haul their loads over considerable obstacles such as deep road ruts, shallow side ditches, low banks, etc.

THE HOWITZER

A more graceful and well proportioned piece of ordnance could not well be imagined than the German 42-cm. gun. The bore between the lands measures exactly 42 cm., although the gun does not look this large. The thickness of the metal at the muzzle is surprisingly thin, not over 3½ inches by estimation. The length of the gun over all is exactly 5 meters, determined by measurement. The diameter of the breech is about four feet. The fermeture is the well known Krupp sliding block and is completely opened or closed by three turns of the operating crank.

PERSONNEL

The personnel of the battery consists of 280 men, commanded by a captain. Of the men, 200 are foot artillerists and the remainder are chauffeurs and mechanicians, most of them from the shops of the several motor truck manufacturers and from the Krupp works. An ordnance expert from the Krupp works was attached to the battery as a Lieutenant of the Reserves. In the actual firing of the battery, 25 artillerists were required at each piece.

AMMUNITION AND RANGES

The shell weighs about 820 kilogrammes, or about 1800 pounds. It is about 3½ or possibly 4 calibers long, and has the ordinary ogival head. The powder charge is contained in a large brass case about 18 inches high. The most effective range, namely the one giving the maximum accuracy, was stated to be 9400 meters. The maximum range is much greater, but no information would be given on this point. The ammunition is transported in a special motor truck column which was not encountered, and no details as to loads or number of wagons could be obtained.

FIRING

On October 8, 1915, this battery was observed while firing on the English position at Loos, for which purpose it had been emplaced in a quarry pit pertaining to a cement mill near Estevelles. The floor of the pit was about eighteen feet below the general surface of the ground, and is entered by a ramp with a slope of about 1/8. The howitzers were set up close to the almost perpendicular bank of the pit, about 150 feet apart. On each side of each piece was a shell and powder store, formed by a slight excavation in the bank and covered by paulins.

In loading, the pieces are brought to a horizontal position. A shell is brought from the shell store on planks laid on the ground and placed under the loading crane, from which is suspended a shell tray. The shell is rolled on the tray and clamped in place, a brass case with the powder charge is set on the frame forming part of the tray, and the whole load hoisted by the crane, six men operating the hoisting crank located near the end of the tray, three on each end. The tray is centered in the breech and the shell pushed into the chamber. The rammer staff, which is comparatively short, has knotted ropes fastened to its rear end; these ropes are led forward and, with some dozen men manning the staff, the projectile is rammed into its seat, giving forth the clear metal ring that indicates good centering. While ramming, the men stand on the trail of the carriage and on the upper surface of the spade. The brass case containing the powder charge is then lifted from its frame and pushed into the powder chamber, after which the piece is elevated by the elevating crank in the front and traversed by the traversing gear in the trail. Sighting was, of course, indirect, the sighting point being a staff planted in the ground beyond the rear edge of the pit. Firing was by lanyard, the man pulling same sometimes standing on the ground and sometimes remaining astride one cheek of the carriage and taking a short hold on the lanyard.

The recoil of the gun is about four feet, and it moved back and forth easily without jar. Careful observation of the spade failed to disclose any visible motion. As the battery was fired at ranges from 7600 to 7800 meters (8311 to 8530 yards), the elevation was considerable, apparently about 60 degrees. The high elevation, as well as the firm stony ground of the quarry, were both favorable to checking horizontal motion. It should be stated here that the cradle has two recoil cylinders and two return cylinders, one each above and below, and surprisingly small for so powerful piece of ordnance. A slight splinter proof steel shield is also attached to the front of the carriage.

Fire control was from captive balloons and possibly also from a land station as it was stated that fire was being observed from three points. After each shot, the results were telephoned to each gun, there being a telephone station between the guns. The blast effects were considerable, but not disagreeable to observers standing on the edge of the quarry pit in rear and about 80 feet from the guns. The roof coverings of the buildings of the cement mill, located about 150 feet in front, were lifted and dislodged. The battery fired seven shots in twenty-nine and a half minutes by actual timing, counting from the first shot. There was not a single hitch or delay with either piece, although this was the first time the battery had been fired in the field, it being entirely new and fresh from the Krupp works at Essen.

WEIGHTS

The weights of the loaded wagons vary somewhat, but average about

15 tons. The motor tractors also vary, those of wagon No. 1 being the heaviest and also weighing about 15 tons. On fairly good and level roads the battery travels about 10 km. per hour.

The type of 42-cm. mortar, mounted, for utilizing the ordinary railroad track both for transportation and for firing can be described as follows:

The piece and the carriage, as shown in Fig. 1, are mounted on railroad carriages 18 meters (20 yards) long, supported by two trucks having three axles each distance from center to center being about 12 meters (13 yards).

This mounting on trucks affords the advantage of turning easily on short curves. The middle of the platform which is very strong and capable of being lowered, carries a turntable revolving on rollers on a circular rail of 2.80 meters (3 yards) diameter.

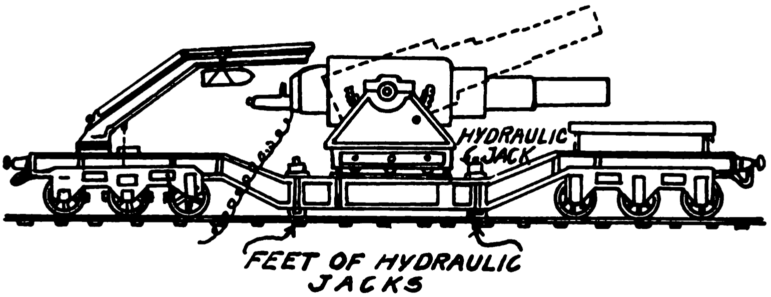


FIG. 1.

1956

This turntable supports the carriage and the piece; the rotation of the piece for aiming in azimuth and even the laying for elevation are accomplished by means of hydraulic transmissions and segmental racks.

The piece itself comprises the cannon proper, the cradle, and the hydro-pneumatic recoil system.

The cannon tube is built of forged steel and slides in the cradle where it is guided by two runners.

The cradle has the trunnions in its forward end, and in the back a semi-cylindrical part attached to the recoil system. This latter comprises essentially two hydraulic glycerine brakes and an air accumulator.

At one of the extremities of the platform is a small crane which is used for taking the projectiles from the ammunition car and placing them in the piece which is brought to a horizontal position for loading.

The piece fires a projectile of about 900 kilos (1980 lbs.)

with 120 kilos (264 lbs.) of picric acid (melenite) or of trinitrate of toulene, and has a range of about 14 kilometers (15,300 yards) when fired at an elevation of 45 degrees.

The piece is fired from a distance by electricity. Each shot costs about 13,000 francs ($2600). The rapidity of fire is one shot in six minutes. Moreover, it seems that the piece can fire only about fifty shots before becoming unserviceable.

In addition to the truck platform, the train of the 420-mm. mortar comprises a locomotive with tender, a first car for the personnel, another for ammunition, and a third containing an oil motor for running the dynamo and accessories for transmission.

The piece with its platform weighs 110 to 120 tons, the entire train about 300 tons. The piece is put in battery by chocking the platform on the track and on the ground by means of hydraulic jacks so as to take the weight completely off of the trucks.

It appears that there is another model of the 420-mm. weighing 97 tons, which is transported over roads and set up on a concrete platform.

It is said that a dozen of these 420-mm. mortars were participating in the battle of Verdun.

In addition to the two large types of ordnance just described, at the outbreak of the war Germany had 190 4-gun, 6-inch howitzer batteries; a number of 10-cm. (3.94-inch) and 13-cm. (5.12-inch); some 28-cm. (11.02-inch) field mortar batteries and 21-cm. (8.27-inch) howitzers.

The successes of the 42-cm. mortars, and the excellent results secured from this weapon have steadily spurred the Krupp Company to the development of even a larger gun, and from the reports current, they have perfected a 54-cm. (21-inch) gun which has a range of something like 38 miles.

AUSTRIA

Austria was a little behind Germany in inventing heavy artillery to be transported on railroad cars and motor trucks, but her development of the famous "Skoda" howitzer, previously described, was of great value to both countries during the first few months of the war.

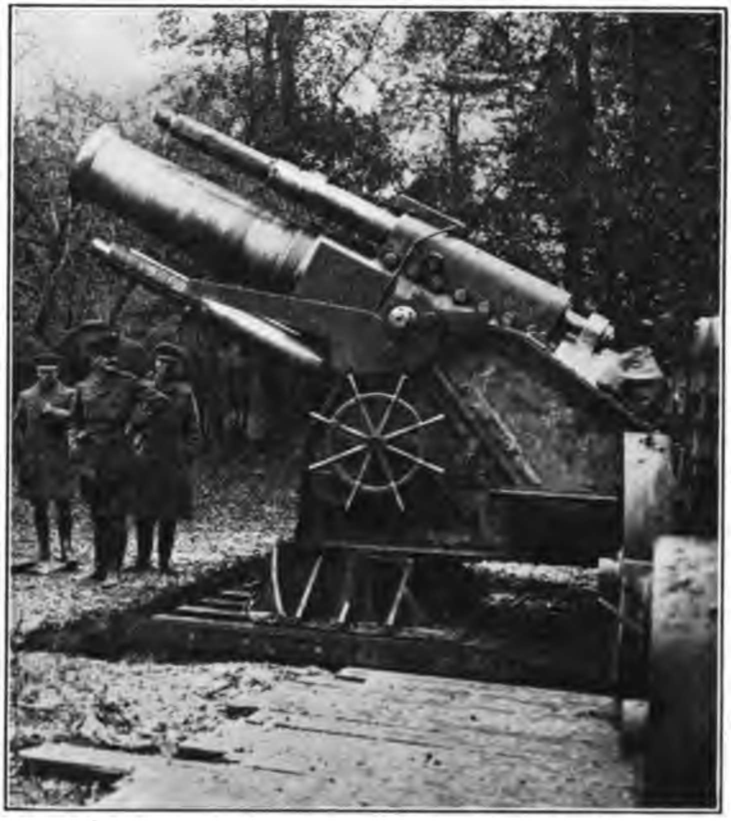
In the great offensive by Austria against the Italians, reliance was placed in her large concentration of artillery. Allowing that seven army corps were engaged in the attack, the normal equipment of artillery would have been 1300 field pieces, 216 4-inch field howitzers, and 56 6-inch guns. Hillaire Belloc in an interesting analysis of this question states that the Austrians tripled the number of 4-inch and 6-inch howitzers; that they had 4 15-inch and 4 16½-inch howitzers; that the total number of guns was 2422. He makes a point that because of the limited railway accommodations, it will take the Austrians in their retreat several weeks to remove to another front this mass of artillery and its enormous stores of ammunition.

FRANCE

The following statement made early in the war by a French authority well illustrates how much reliance the French placed on their 75-mm. gun:

> The characteristics of our 75-mm. gun are well known. It is a perfect solution of a number of mechanical problems. The cannon is the actual master of the battlefield. It renders progression of troops impossible by covering the ground with shells. Out light piece can rain close to 30 shots per minute, and a number of these pieces permits covering the entire field with an impenetrable barrier of fire.
>
> To advance, the artillery must be reduced to silence. Here, as at sea, the fight is decided between specialists, and between specialists of that arm which has attained to the maximum force. A preliminary duel takes place between the opposing long range artillery. Superiority on the field will be all the more indispensable as the proportion of heavy artillery increases. The victor will be the sooner able to assure liberty of action to the lighter artillery, and then he will be master of the field. But his success will be limited and retarded by the resistance of the trenches, and we must also remember that the situation is rendered more complicated by the intervention of aeroplanes.
>
> The French heavy mobile artillery at the outbreak of the war was negligible—she had some 6.1-inch rapid fire guns, 4.7- and 6-inch guns, and old 8.66-inch guns and 10.66-inch mortars.
>
> German progress quickly reversed the French idea in the first few months of the war and caused a rapid construction program of heavier guns to be put into effect.
>
> Since the beginning of the war these calibers have been perfected and France is now hammering back at the Central Allies.

Both the French 12-inch and 13.8-inch naval guns are transported on railroad cars and fired from their traveling carriages. These carriages are arranged so that the down thrust in recoil is taken up by transmitting and distributing the stresses to a suitable base and in that way relieving the traveling trucks of the strain. It is understood that the Allies have had some difficulty along that line and that now no attempt is made to fire guns of calibers greater than 7-inch without the arrangement of some form of suitable base. It will be noted from an inspection of the photographs published in this country that all the nations at war, whether through design or otherwise, have been extremely careful not to show too much in detail any of the mounts used in transportation.



American Press Association. 1957

FIG. 2.
BRITISH HOWITZER IN FIRING POSITION

With all these new mounts, the handling of ammunition is a problem and when no loading platforms are available, it becomes a question of cranes and blocks or some other quickly improvised means to get the projectiles into the guns. Information in this regard is not as yet very plentiful.

In May, this year,[1] the French used their 14.6-inch mortar at Verdun and its results were so good, it is understood, that

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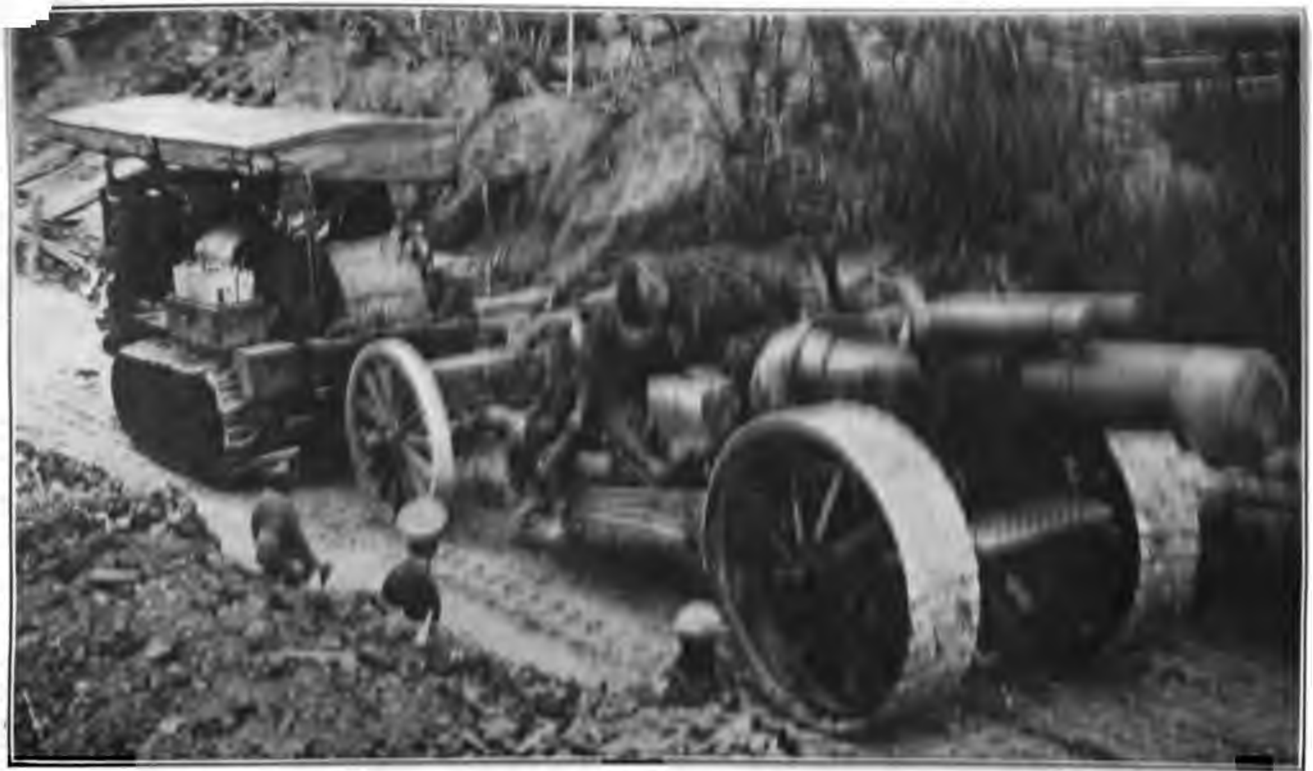
[1] 1916.



Pach Photo News, Inc.

FIG. 3.
BRITISH HOWITZER BEING HAULED TO THE FRONT

the design has been approved and that others will finally be made. This mortar can be transported either on special trucks or on railroad cars.

ENGLAND

At the outbreak of the war England was in practically the same position as regards heavy mobile artillery as France—if anything, a little worse off. Strenuous efforts have been made since and we now find them following closely to the French development.

Due to the great efficiency of the English censor, very little descriptive matter seems to be available, but sufficient photographs have been published to convey to the trained eye at least, the information that England has guns of at least 12-inch caliber mounted on railway carriages.

OTHER NATIONS

Russia was practically without heavy mobile artillery and, to date, little has been heard of her development of any. However it is probable that Japan is supplying some guns of large caliber by this time and it is known that a number of tractors have gone into Russia.

Italy was a little better off than either France or England, and as soon as the Austrians' operations commenced greater activity in the development of howitzers was apparent.

While the information of the method used in firing the larger caliber guns from railroad cars is meager, it is thought generally this result is obtained by attaching to the ground, when the car is not in motion, supports which take the weight off of the wheels. These supports transmit the shock to the ground and thereby take the stress off of the axles, wheels, and rails. The French have railway trucks for practically every model of their heavy artillery from the 6-inch to the 12-inch. Large pieces of siege artillery are generally fixed to masonry platforms but the railway still serves to transport them to the scene of operations.

The question presents itself as to what is the largest caliber capable of being mounted on a railway chassis. The load limit of an ordinary freight car is 10 tons, or five tons per axle. By dividing the load among a large enough number of axles, the French have fired from a railway car a projectile representing a recoil of 100 tons; that is to say a caliber of 38 to 45 centimeters, depending on the length of the gun and the weight of the carriage. It would appear that the German 42-cm. was manufactured as a reply to this most important question.

The problem of the use of heavy artillery on railroad cars and motor trucks is of the greatest importance to us today. Its uses in the present European war contains the solution of out coast defense problem, if we are wise and profit by it.

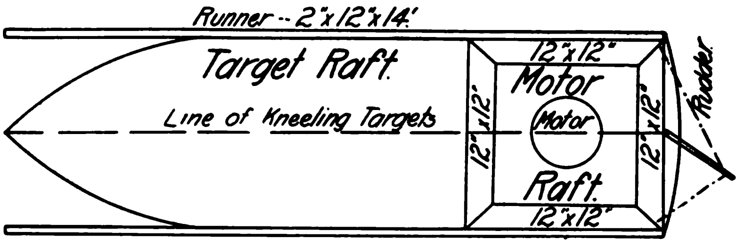
AN AUTOMOBILE TARGET FOR LAND DEFENSE GUNS

By Captain LE ROY BARTLETT, Coast Artillery Corps, U. S. Army

Description

This target consists of two rafts. One of these rafts, called the *target raft*, is formed by two twelve-inch by two-inch runners fourteen feet long and placed three feet apart, floating edgewise. These runners support a light framework, either of split bamboo or a light wooden structure covered with target cloth to represent the sides of a boat.

The other raft, called the *motor raft*, is a box three feet square made of twelve-inch by twelve-inch timbers with sufficient buoyancy to float a motor of the Koban or Evinrude type independently of the target raft. It is armored over the top with a piece of one-quarter inch boiler-plate as a protection against shrapnel bullets and also to keep the ignition system dry in rough weather. As an additional precaution, a buoy with a proper length of rope is attached to the motor so that it can be recovered if sunk.



Operation

The target is towed to some convenient spot, the rudder fixed at any desired angle, and the motor started.

Advantages

This device provides a target that may move either in a curve or on a straight line in any direction, i.e., directly away from or directly toward a battery.

It is cheap, easily constructed, and can be made from and repaired with materials usually on hand at a fort.

The motor, being detachable, can be used on a row boat to furnish a target at daily drill.

PROFESSIONAL NOTES

NAVAL STATIONS AND NAVAL BASES[1]

By Captain A. P. Niblack, U. S. Navy, Vice-President

It is important that this country awaken to its strategical requirements in the Atlantic, Pacific, and Caribbean, and, as the principles governing the selection and outfitting of naval stations and naval bases are not generally recognized, it is the intention here, as briefly as possible, to touch on the elements of the problems awaiting us. That type of statesmanship which attains its highest ambition in securing a naval station as a local improvement at national expense, and that type of citizenship which secretly hopes that there is some cheap, honorable, and unannoying way of saving the nation at reduced rates will derive cold comfort from the actual facts.

There are special considerations, in the case of this country, which require clear recognition:

1. We are the only country facing equally on two great oceans with full responsibilities on each.
2. We are, in our relations with other powers, practically an island with widely outlying colonial possessions in the Atlantic, Pacific, and Caribbean.
3. We are committed to the policy of forming no alliances, and must go it alone.
4. We are the sole remaining country not to adopt the principle of universal military service as being synonymous with the great democratic principles of equality before the law, equality of opportunity, and equality of responsibility.
5. We are the sole remaining country in the world in which the coast defense is not entirely, or almost entirely, in the hands of the navy.[2]
6. We are the sole remaining victim in the whole world of the voluntary military system which is enormously expensive per unit, prohibitive in the cost of providing "adequate" personnel for the land and sea forces, and foolishly extravagant in pensions, in the cost of recruiting, and in the inducements, pay, and "bounties" which it is necessary to offer.
7. A large percentage of our population consists of undigested and unassimilated foreigners of whose individual loyalty we must entertain serious doubts.

When naval and military authorities are confronted with the task of drawing up war plans, in time of peace, they must ask themselves a lot of questions such as the following:

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[1] Read at the twenty-fourth general meeting of the *Society of Naval Architects and Marine Engineers*, held in New York, November 16 and 17, 1916.

[2] The coast defenses of Great Britain and Japan have not come into the hands of their navies. The naval policy of these countries is aggressive. History shows that navies which are charged with the duty of coast defense have a strong tendency to assume a defensive role and become mere adjuncts of the shore defenses. (Editor.)

What is the best thing to do, not with what we ought to have, but with what we actually have and can expect to have?

Is our particular policy which threatens trouble in a given locality, or with a given nation, vital to us, and does it threaten a vital interest of the other nation?

Would a war in support of such policy involve us with other countries?

How far will it be necessary for us to go to force our policy on the other country, and, in case of war, to what limits would our people be willing to go to continue it?

Would both nations throw their entire strength and resources into a fight to the death?—that is to say, would the war be a limited or unlimited one?

Are there local (domestic) or foreign (international) complications which will force us to adopt a defensive strategy, or may we count on an offensive, or what would ever be in our case, situated as we are, an offensive-defensive?

In case of war, shall we attack at once or leave the initiative to the enemy?

May we plan to fight with the nation as a unit behind us, or may we expect interference and confusion from local politics, or indifference and lack of public sentiment to sustain the war?

Let us, however, assume that wise statesmanship, patriotic sentiment and national spirit are back of us.

Fortunately, in times of profound peace, naval strategy in the unobjectionable form of peace strategy enables us to absolutely forestall the possible actions of other countries in any given area, and, while enforcing our own policy, may make resistance or war inadvisable on the part of another country which may oppose such policy. Thus has the British Empire been consolidated.

We recently, by treaty, secured control of the Nicaraguan canal route with the necessary terminal bases at the Corn Islands in the Atlantic, and in the Gulf of Fonseca in the Pacific. We have, in our actual possession in the West Indies and in the Pacific, absolute treasure islands of strategy for the location of those advance and outlying bases necessary to supplement the fleet we are building, which will jointly guarantee us that measure of command of the sea as will give us the national security which we all crave and which, at this moment, to our peril, we actually lack. It is merely a question of intelligently willing to do it, and then putting up the money. In doing it, in time of peace, we offend no innocent country, but we might bring on a war by undertaking even a small part of it during a time of strained relations. No one waits until it rains to begin repairing the roof.

To establish ourselves securely within the political areas in which our manifest destiny lies not only removes temptation from other countries to try to overreach us, but protects us from that danger to ourselves which comes from using strong diplomatic language without the real power to make it good. The siren and lulling words of interested countries are not a safe foundation on which to build the national defense.

To outline our peace strategy, let us assume that, among all our navy yards and stations on the Atlantic Coast, our two main bases, to be decided upon, are, say, New York and Norfolk. New York, as the assumed center, and Boston and Philadelphia on the periphery of the circle enclosing the

al area of the United States, become the true strategical center
ve deepen the Cape Cod and the Delaware and Raritan canals
nals, clear the East River of all obstructions from the Battery
land Sound, and adequately fortify Block Island, Vineyard
zards Bay and Cape Cod Bay regions. With exits at Delaware
Hook, Block Island, and Massachusetts Bay the entire British
t exists today, could not contain our own navy as it is, although
ually able to contain a much larger and more powerful one, the
avy, even with the two exits it has by virtue of the superb Kiel
ur "Heligoland," Block Island, is now only a summer resort,
ded as it should be, it would be the armed sentinel at the gate.
on around New York, of which we speak, represents billions of
and the expense of providing mobility to our naval forces and
to the area would be but a fraction of one per cent. As a mere
cial proposition the enlarged waterway would pay without the
d mines to secure it, in case of war, and the present serious trend
ic opinion makes the whole question one of easy possibilities. The
es of Cape Cod Bay, Narragansett Bay, New York Bay, and Delaware
re one and the same question, and the area from Boston to the
are Breakwater is our main strategical area.

r second considerable strategical area is that of Chesapeake Bay,
acing Washington and Norfolk—that is, the national capital and an
nsely important naval base. It is far along in our plans to speak of
very desirable proposition of the Delaware and Chesapeake Canal as a
canal, but it is easy enough to see what it would add to the mobility
ur naval forces and to the security of our coasting trade in case of war.
t now the adequate defense of Chesapeake Bay entrance is the main
sideration, for we have left that "stable door" wide open, as we have
o the Delaware Bay entrance. It is therefore idle to talk too much
eory when our practice is so elementarily careless.

The first commanding strategical point, in connection with the Panama
anal and its approaches, is Key West. Mahan, in his "Naval Strategy"
p. 317), says, "There is nothing that can be said about the interests of
he United States in the Panama Canal, as connecting the Atlantic and Pacific coasts, that does not apply with equal force to the Straits of Florida as uniting the Atlantic to the Gulf of Mexico and the Mississippi Valley." Its main importance is in its relation to Cuba, whose political integrity we are pledged to defend. Cuba is, in effect, as far as Guantanamo is concerned, the absolutely undefended mainland of the United States, since it is up to us to defend it from invasion—and we have taken no steps thus far to do so.

In considering the defense of the approaches to the Isthmian Canal route in the Atlantic and Caribbean, the most striking fact is the commanding position of Great Britain, with Bermuda less than 700 miles from Cape Cod, Sandy Hook, and Cape Henry, and with the Bahamas, Jamaica, St. Lucia, Barbadoes, and Trinidad commanding the approaches to the canal from all directions. While we all habitually assume the benevolence of British policy toward us, it is not a justifiable strategic assumption. One should not leave his business affairs entirely in the hands of anyone else, if it can be avoided. Fortunately we already possess the necessary positions to secure the approaches to the Caribbean against all comers, and all we need is the sagacity to add to the strategical positions the necessary strength, resources, and mobile defenses to make them good. We have the tactical defenses of the Panama Canal itself well under way and well understood; and we have Guantanamo "on the mainland," dominating Jamaica, and the Windward Passage; but we have over and beyond all Culebra Island, the neutralizer of Bermuda and the British West Indies positions—the ideal outlying strategical base—situated 20 miles east of Porto Rico and 20 miles west of the Danish island of St. Thomas. For the price we could possibly purchase the Danish West Indies we could make them useless strategically to anyone else by spending the money on Culebra, only 20 miles distant from St. Thomas.

Almost every drawback that may be glibly cited against Culebra as our great naval base for our fleet in the Atlantic is really an advantage. For instance, it is usually argued that the island and its harbor are too small, whereas, if anything, the island is too large, and the harbor could be even smaller before it would cease to be ideal. Of course it is out of the question to expect to find a ready-made naval base, and we are in luck to have all the treasures we have. There is above all no question of Culebra versus Guantanamo, because the latter merely supplements the former. There may be a Culebra without Guantanamo, but no Guantanamo without a Culebra, because Guantanamo is on the undefended mainland, and, with Culebra securely held, it would be on the flank of an attacking expeditionary force operating against Guantanamo. As Mahan points out in his "Naval Strategy";—"In short, as to the Caribbean and the Isthmus of Panama, Guantanamo and Culebra can become to the United States what Gibraltar and Malta are to the interests of Great Britain in the Mediterranean and at Suez, with the advantage to us that they are nearer our home ports than those positions are to Great Britain." While statesmen abroad sleep with his books under their pillows, and do not sleep well on that account, the writings of the late Admiral Mahan are not so fully appreciated in our own country.

The Panama Canal defenses, although lacking considerable in gun installation, mobile troops and secret service protection, present the ideal of position, strength and resources, in that it is hardly conceivable that an enemy would be strong enough to operate against it in both oceans at the same time, and we may easily maintain uninterrupted communications by way of either the Atlantic or the Pacific, whichever, at the time, is not under the enemy's control.

On the Pacific coast we recognize the importance of two home bases, one on San Francisco Bay and the other on Puget Sound, and so it remains to consider the question of outlying and advance bases in the strategy of the Pacific. In his splendid book on "Naval Strategy" Mahan says:

"Through the Caribbean Sea lie the approaches to the Isthmus of Panama, the place where the Monroe Doctrine focuses. The Caribbean still remains important, perhaps it has not even quite lost its lead, but it is now balanced by the Pacific * * * National policy now imposes naval stations in the Pacific * * * The selected ports, however, in both oceans obviously can and should form a well-considered system, in which the facilities and endurance of each part shall be proportioned to its relation to the whole."

It will be noted that the positions which Germany held in the Pacific are now held, possibly only for the moment, in other hands, thereby upsetting that balance of positions which gave no one country too great a dominance for our own future good. We have, to be sure, recognized the singular strategic importance of the Hawaiian Islands by half-heartedly providing some of the defenses of Oahu Island and Pearl Harbor. Anyone really alive to the actual situation in our Pacific possessions must feel grave misgivings as to our future on that ocean. An ounce of prevention now is worth several tons in the future if our relations become strained, and the remedy lies in intelligent appreciation and conservative but definite action.

Without going too deeply into an analysis of the strategy of the Pacific, there is one thought which we must dismiss from our minds, and that is that we are really ever going to allow anyone to tell us to get out of Guam and the Philippines, or that the moral and economic interests of the world at large will be otherwise than definitely set back by our doing so. To do so voluntarily is enough like the proposition of removing both hands from a sheet of fly paper to make it difficult to appear graceful in doing so. On the contrary, history will vindicate the acquisition of the Philippines as an act of broad statesmanship, through which we will eventually solve the question of our economic relations with the peoples of the Far East by that exhibition of moral and physical purpose which alone satisfies the oriental mind. Soft words and evasion of issues get you nowhere in diplomacy, and only intrenched position is useful in strategy.

It is an historical fact that no great naval battle has ever been fought in mid-ocean, but always near the bases of one or the other powers, and the ports of supply, or naval bases, indicate the direction of the line which operations must take in time of war and which become lines of communications once the fleet has advanced beyond any one naval base on the route. We already have in the Pacific the heart's desire in strategical positions, and we only seem to lack the knowledge and nerve to strengthen such of them as will permit us to take the initiative and thereby forestall and even prevent war by making it too hopeless for anyone else to take the chances. It is a game of checkers, with our advantage against the whole world as far as mere positions go. It is clearly in our power to compel the strategy of the Pacific in time of peace in such a way as to avoid the possibility of war. Pacifists who preach disarmament as a means of avoiding war are safe enough on the paid lecture circuit but to be pacific in the Pacific is to be the strong man armed—and there is no other way. That we will ever be so armed in the Pacific no one can believe who recognizes the potency of local and political interests in absorbing the substance which might better go to the maintenance of the two arms of national security, viz., a well-paid and well-trained diplomatic corps and a chain of naval bases for our stay-at-home fleet.

Any consideration of the strategy of the Pacific is utterly futile which leaves out the erection of Guam into a great naval base as our key to it for all time—our far-flung outpost of "peace in the Pacific" through armed power in repose. Other positions which we now own, such as Tutuila (Samoa), Dutch Harbor (Unalaska), Sitka, Midway Island, Corregidor, etc., are questions of definite offensive or defensive areas, or of shortening lines of communications, and as such are worthy of consideration as strategic points, but our first necessity is the extension of the defenses of the Panama Canal and Pearl Harbor. Then come Culebra and Guam as great insular bases.

Meanwhile the other strategical points above enumerated should be treated, for the time being, as possible advance bases; their harbors should be cleared of obstructions, and the necessary equipment prepared accordingly. Even Guantanamo may be, for the time being, regretfully placed in the advance base class.

The problems of our national strategy are so vast and yet so lightheartedly disregarded that it is essential that naval officers and army officers who know the real situation should have with them the intelligent understanding and co-operation of all intelligent citizens. Half measures give foreign nations a great advantage when diplomatic relations are strained, because they compel a temporizing policy at critical times, for it is then impossible to do anything in the way of hasty preparation, because it will only precipitate war.

An accompanying chart, similar to that in last year's Proceedings of this Society, shows at a glance the outlines of the problem of our strategy, with the Panama Canal in working order. What it would be with the canal blocked is another question. The defense of the canal is therefore the prime requisite of our national policy.

We require naval stations and naval bases to correspond with our policies, with our strategy, and with the requirements of our fleet. It means the expenditure of millions of dollars and is the price of that empire which is ours by destiny, by geography, and by the blood this nation has already shed, but which empire will surely crumble if we sit back.

That preparation in time of peace can only be called adequate which leaves only mobilization as the remaining step in strategy if war unhappily comes. We know what our resources and land and sea forces are, and also those of other nations. We know what our own and other nations' policies are. Our strategy must fit what we have, and if we have little we can do little. The apparent difference of opinion among naval officers as to the needs of the naval establishment, when called upon to enumerate them, is largely merely a difference in the values assigned to the various elements of sea power and the exigencies of the moment, considering how much our strategy lacks in so many directions. At any rate our military and naval establishments are adequate when they—

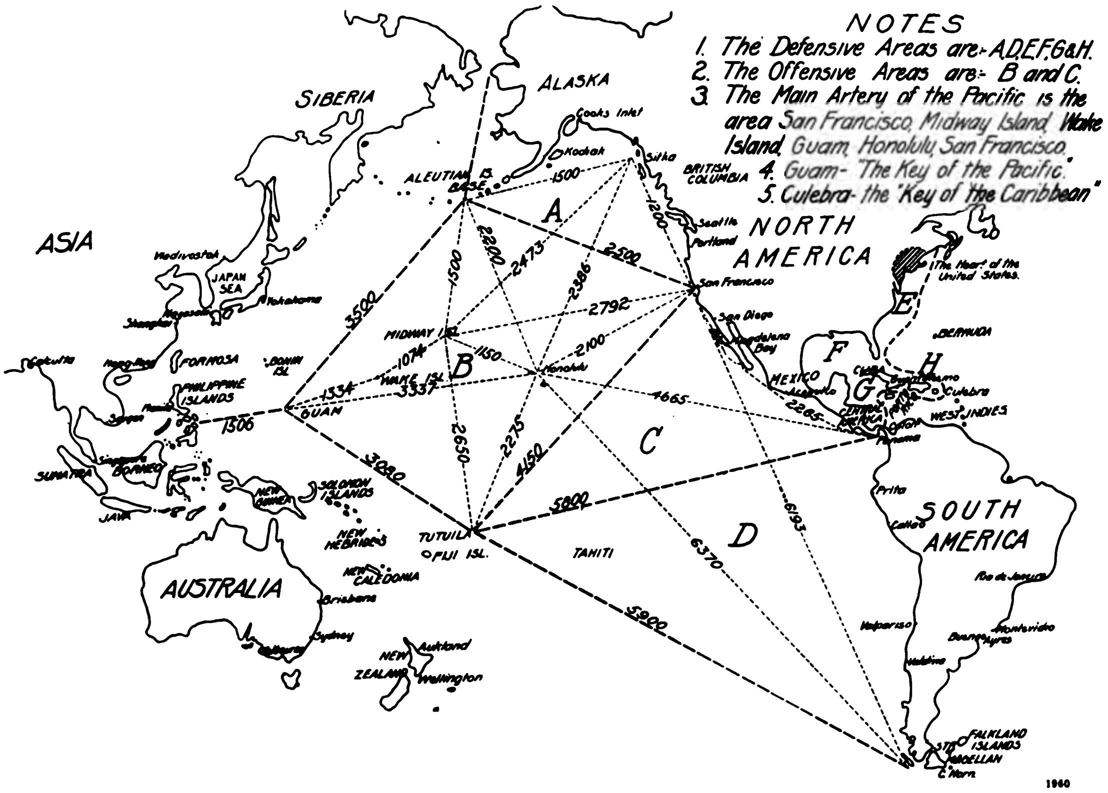
a. Are superior in *matériel* and *morale* to the corresponding forces of a probable or possible enemy.

b. Correspond with the requirements of the Monroe Doctrine and the defense of the Panama Canal.

c. Answer the main requirements of our strategy.

As one writer expresses it, "The fundamental condition of success in war is harmony between policy and strategy." Policy may be defined as the attitude or course of action of a nation which influences its relations and intercourse with other states, and as examples we may cite, in our own case, the "Monroe Doctrine," "Asiatic Exclusion," the "Open Door in China," the "Freedom of the Seas," and the defense and control of isthmian canal routes in Central America. Strategy may be defined as the assembling, distributing and directing, in any given area of possible or probable hostile operations, of all the armed strength and resources of a nation to best secure the limited and definite objects of a policy, or war growing out of a conflict of policies.

Mahan says, for instance, that the "Monroe Doctrine is only as strong as the United States Navy." That is about true of all of our policies, and it is high time, among other things, that we take up the consideration and


NOTES
1. The Defensive Areas are:- A.D.E.F.G.&H.
2. The Offensive Areas are:- B and C.
3. The Main Artery of the Pacific is the area San Francisco, Midway Island, Wake Island, Guam, Honolulu, San Francisco.
4. Guam- "The Key of the Pacific."
5. Culebra- the "Key of the Caribbean"
A
B
C
D
E
F
G
H
ASIA
SIBERIA
ALASKA
NORTH AMERICA
SOUTH AMERICA
AUSTRALIA
Cooks Inlet
Kodiak
Sitka
BRITISH COLUMBIA
Seattle
Portland
San Francisco
San Diego
Magdalena Bay
MEXICO
Acapulco
CUBA
Guantanamo
Culebra
PORTO RICO
CENTRAL AMERICA
Colon
Panama
WEST INDIES
BERMUDA
The Heart of the United States.
Prita
Callao
Rio de Janeiro
Montevideo
Buenos Ayres
Valparaiso
Valdivia
FALKLAND ISLANDS
STR. MAGELLAN
C. Horn
ALEUTIAN IS. BASE
MIDWAY ISL.
WAKE ISL.
Honolulu
GUAM
TUTUILA
FIJI ISL.
TAHITI
Vladivostok
JAPAN SEA
Yokohama
Nagasaki
Shanghai
Calcutta
Hong Kong
FORMOSA
BONIN ISL.
PHILIPPINE ISLANDS
Manila
Saigon
Singapore
BORNEO
SUMATRA
JAVA
NEW GUINEA
SOLOMON ISLANDS
NEW HEBRIDES
NEW CALEDONIA
Brisbane
Sydney
Melbourne
NEW ZEALAND
Auckland
Wellington
1500
1200
2200
2473
2386
2500
2792
3500
1500
1150
2100
1074
3337
1334
1306
4665
2265
2650
2275
4150
3080
5800
5900
6370
6193
1940

study of the question of naval stations and naval bases on the basis of our strategy and the needs of our fleet, rather than on the narrower lines along which such questions are now settled.

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MILITARY AND TECHNICAL CONSIDERATIONS OF BATTLESHIP DESIGN[1]

By Naval Constructor R. D. Gatewood, U. S. Navy (Member)

The whole history of warship design has been a long series of steps towards increased displacement, and, except for our own battleships *Idaho* and *Mississippi*,[2] and one or two classic examples abroad, there have been thus far practically no backward steps. By studying, even casually, the progress of the science of building warships, one is at once struck with the fact that the improvements effected in the various types have been made possible largely through this increase in displacement. The true influence that may be ascribed to increased size has been greatly confused because of many concurrent changes in other features of ship design and operation; stronger materials have made it possible to build lighter hulls, to use higher steam pressures, and to install more powerful guns; new types of propulsive machinery have resulted in increased speed or greater fuel economy; improved processes of manufacture have decreased cost of construction. Always, however, an inevitable law of growth has asserted itself, and each successive vessel of every class has been larger than its predecessors.

In the case of battleships the tendency toward greater displacement would have been even greater were it not for two very important and practical objections:

1. The extreme reluctancy on the part of governments to spend such large and always increasing sums on single units of power.
2. The great difficulties in providing docking and harbor accommodations for vessels of the giant size demanded by those responsible for using these vessels in battle.

Means have been devised, as, doubtless, means will continue to be devised, to overcome these objections, but is there not a limit to this increase in dimensions? If so, what are the governing considerations that are likely to determine this limit?

The problem of the United States, or, indeed, of any other country, is not so much whether its needs may be served best by large or small battleships, because, after all, the terms "large" and "small" are vague and relative in the extreme, but, rather, what are the minimum dimensions of the ship that will best meet out needs?

These dimensions are influenced and determined by four factors:

1. Our national policies.
2. Considerations of strategy and tactics.
3. Technical limitations.
4. Cost.

Let us cast aside all preconceived ideas as to size, and analyze with an open mind the influences of each of these governing factors on the military and technical characteristics of battleship design. From the facts developed by this analysis, let us then try to arrive at our minimum dimensions, bearing in mind always that the design thus determined merely gives "expression to the technical ideas and intentions of the epoch."[1] Also, that one should "hesitate to go on record for all time, as the rapid changes in conditions, improvements in material, and increase in knowledge, make it desirable to reserve the right to change one's mind in order to keep up with, or go ahead of, the procession."[2]

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[1] *Society of Naval Architects and Marine Engineers*, New York, November, 1916.

[2] These were the battleships sold to Greece.—Editor.

STRATEGY, TACTICS, AND DESIGN

Besides recommending a building programme providing for the number of battleships to be constructed each year, the General Board defines the military characteristics of our battleships, namely, the size and arrangement of battery, extent of protection, speed, and radius of action, indicating the relative importance of the various main features. This definition of military characteristics is reached after having compared our national policies with those of other States as to the most probable sources of conflict, and after having considered the numbers and types of battleships of out most probable opponents. In arriving at these decisions the most valuable aids are the data derived from the analysis of the strategical problems and tactical studies of the war-game worked out either by the gameboard of the War College, or by the movements of actual ships of the fleet simulating a naval engagement. These studies have shown conclusively that—

Under modern conditions the gun is the principal weapon of the battleship; and concentration of superior gun fire at the decisive point at the critical time, is always the key to victory.

With equal units, naval gun power can be assumed to vary as the square of the number of guns that can be brought to bear.[3]

The mere possession of a greater number of units is useless unless this superiority in number can be employed in a concentrated way at the proper time.

There should be no reserves in a naval battle.

"The entire force should be brought into action as nearly simultaneously as possible, so distributed as to afford mutual support, and if practicable in such a manner as to isolate a part of the enemy from the battle while the remainder is being defeated."

Reasoning from the above premises, it is obvious that concentration of armament constitutes an overwhelming advantage, and is, in fact, an absolute necessity. The great length of battle line, and the great difficulties in maneuvering, due to the number of units in the present day fleet, imperatively demands that, from the point of view of gunfire, as many main battery guns as possible should be concentrated on as few units as possible.

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[1] Admiral Sir Cyprian Bridge. Paper before Jubilee Meeting, Naval Architects and Marine Engineers.

[2] Ex-Naval Constructor R. H. Robinson. Paper before Naval War College, August, 1911.

[3] "Suppose F_1 F_2 opposed to A, all three being identical ships, each capable of firing one round a minute, and assumed to be put out of action by four rounds. A would be destroyed by $F_1 + F_2$ in two minutes. $F_1 + F_2$ would be destroyed by A in eight minutes. Therefore $\frac{F_1 + F_2}{A} = 4$. That is, the fighting value of two vessels fighting one is four times as great as that of one vessel fighting two. Similarly, three vessels fighting two would stand to them, in point of fighting value, in the ratio of $\frac{9}{4}$." See Baudry, *The Nava Battle*, page 99.

ARMAMENT

As long as the gun continues to be the major weapon, the main function of the battleship will be to provide the best possible platform on which to bring it into action. Our guns should possess greater power and destructive effect than those of our most probable enemy, and, since they are now no larger, we must allow for even greater calibers than we have heretofore used. While it is true that in penetrative effect the 14-inch gun at probable battle ranges can pierce any armor that it is practicable to mount in a ship, still, if we accept the principle of maximum destructive effect, we are led almost inevitably to a 16-inch caliber. Such a gun is well within the limits of the present state of the ordnance art, and possesses 30 per cent more destructive effect than the present 14-inch gun of our most probable enemies. The rapidity of fire of the larger gun can be made sensibly equal to that of the smaller, and the heavier weight of projectile will allow us to adopt a relatively low muzzle velocity, by means of which both erosion and dispersion will be diminished. Such a gun possesses a materially greater range, and the priority of gun fire thus gained constitutes a material advantage.[1] It also possesses a greater probability of hitting at long range, and one of the most significant lessons of the European war has been that engagements have been fought and decided at 16,000 yards—a range nearly three miles greater than our past estimate of probable battle range.

There is a further reason why we, of all nations, should adopt the larger caliber. Such a gun materially increases displacement and cost. When the present war is over, we shall be the richest of nations, and, therefore, best able to afford the outlay incident to the adoption of the larger gun. Politically, therefore, this may be highly advisable, because of the depressing financial effect on possible enemies similar to that occasioned by the construction of the Dreadnought class by England.

DISPOSITION AND NUMBER OF BATTERY

Bearing in mind the value of concentration of armament, and having decided the caliber of the main battery, we come to the best arrangement of the guns.

This is largely a function of the battle formation, and until such time as this shall seem to be logically other than line or column of divisions, or simple column, our center-line vertical-echelon dispositions seems best. The question of just how many guns can be advantageously mounted is hardly subject to abstract determination, but it must be quite plain that there is a point at which, after considering the other elements of a design, more guns would only result in a positive loss of efficiency. From a purely constructional point of view, this point has been reached with the four-turret center-line mounting. So overwhelming, however, are the arguments in favor of maximum possible concentration, and so great a length must be provided to obtain the desired speed, that it will probably be best to add one more center-line turret. This is particularly necessary if the 16-inch caliber be adopted, because the problems of mounting such guns in triple-gun turrets are not yet solved, and in no other way can the demands of concentration of armament be satisfied.[1]

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[1] See Baudry, *The Naval Battle*, page 116.

SPEED

For both strategical and tactical reasons high speed is extremely desirable. If we accept the principle that an active offense is the best for defense, speed is essential both for bringing the enemy to action and for maintaining the most suitable range during action. Moreover, speed, when employed in skillful maneuver, assists us to gain that relative numerical superiority which is so essential for concentration. Later on it is proposed to recur to this question of speed in considering the length of battleships, and when the excessive cost of even two knots greater speed than that of the enemy is appreciated, it is altogether probable that we should rely on fast battle-cruisers to gain the above advantages, rather than attempt to attain too great superiority of speed with the battleships.

No other single feature of a ship has so large an influence on displacement, and every fraction of a knot sacrificed will allow the displacement to be reduced many hundreds of tons. Great ships of this type will always cruise in squadron, and the speed of the squadron will be the speed of the slowest unit. This speed is a function of so many variables—condition of bottom, quality of coal, skill of personnel, condition of machinery, danger of machinery troubles at maximum speeds—and the cost incident to any material increase is so unreasonably great that it would seem wiser to adopt comparatively moderate speed.

ARMOR

There will always be a difference of opinion as to the relative importance of guns, speed, and armor, but in no one of these three military characteristics is there such a wide divergence of views as in the case of armor. One authority advocates "external protection," completely excluding the shell; another advocates "internal protection," limiting to a minimum destructive effect after penetration; one advocates protection to vitals only, another complete protection; one advocates vertical side armor, another horizontal deck armor. All admit, however, that at the present time the gun bids fair to be the permanent victor over armor. It is not feasible to mount armor of such thickness and area as to exclude all shell, yet at least we should provide such protection to buoyancy and stability, and to magazines, firerooms, engine-rooms, and other vital parts as will render them, as far as possible, safe from all but the largest shell at normal impact. This can be done with the least expenditure of weight by means of vertically disposed side armor. To protect against shell fragments, and to preserve buoyancy, we must have at least one protective deck located above the deepest possible load-line.

The minimum reasonable requirement of armor, therefore, aside from the local protection of turrets, barbettes, conning-tower, and base of smokepipes afforded by their own armor, is a belt extending high enough above the normal load water-line to protect the stability, buoyancy, and vital military features of the ship, and extending low enough to guard against underwater hits due to naval action, rolling of ship, or heel due to damage.

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[1] For further arguments in favor of restricting the number of turrets to four, see Sir William White's paper before the Society of Naval Architects and Marine Engineers, 1910, and Lieut. Viani's paper in Supplement to *Revista Marittima*, 1908.

Coupled with this there should be at least one protective deck—all to be of the greatest practicable thickness.

PROTECTION AGAINST TORPEDO ATTACK

The gun seems certain to remain the supreme weapon of offense, but this superiority is challenged more and more by the formidable menace of the torpedo and mine. No battleship has ever been provided with any sure defense against either of these dangers, and the weakest feature of all existing battleships is their lack of adequate protection against underwater attack. Even now the largest unit of any fleet can be put almost, if not quite, "out of action" by a single torpedo, and in the future there is little to prevent the use of much larger explosive charges to offset any increased subdivision or underwater armor that may be provided. It seems probable, therefore, that the chief defense against this form of attack will consist in a somewhat increased speed of battleships, and a cordon of high-speed units of the destroyer type. In addition to the protection thus afforded, every possible provision should still be made to minimize the results of successful torpedo attack, and it will therefore be necessary to provide suitable minute water-tight subdivisions and even armor—all of which must add materially to displacement.

This comparatively new effectiveness of the submarine and its weapon, the torpedo, must exercise a powerful influence on the size and cost of individual units, and it is not at all improbable that the eventual development of the submarine may result in driving the battleship from the sea. He would, indeed, be a rash prophet who would venture to predict when this will come to pass, but until then the development of the battleship type must move forward, or else the type must be abandoned altogether.

ENDURANCE

Other great nations of the world as well as the United States have long since abandoned the fallacy of building battleships for coast defense, with consequent small radius of action. As previously pointed out, our battleships should be capable of waging successful war in the waters of our most probable enemies. Since these waters are separated from our own by the width of an ocean, the radius of action of our battleships should be sufficient to traverse this distance to and fro at probable fleet speed, with an additional 2000 miles or so to cover the cruising that may be necessary until contact can be made with the enemy. This would hardly be practicable with a smaller radius of action than 8000 miles at 12 knots. Fortunately, the advent of fuel oil, together with increased efficiency of ship-form and propulsive machinery, renders it possible to meet this claim with comparative ease.

TECHNICAL LIMITATIONS

The above are the most essential military characteristics to be incorporated into the design of our battleships, although there are many others of lesser importance that require due consideration, such as secondary battery, torpedo armament, and type of propulsive machinery. After they are decided the problem presented to the naval architect involves such technical characteristics as buoyancy, stability, maneuvering qualities, and strength. On account of the great number of variables involved, it is capable of numerous solutions of more or less merit, but what we are chiefly concerned with at this stage of the subject is to determine the minimum displacement on which we can expect to meet all these claims.

DESIGN

In the first place the design of a battleship cannot be made according to mathematical formulæ. Many years ago, Rear-Admiral Fiske said that he "labored for several weeks in a persistent endeavor to arrive at some law by which, for a given size of ship, the best combination of speed, armor, and armament could be determined," and that he "failed to find any such law, largely because he did not know the conditions under which the ship would have to fight." But had he known the conditions he would have been no nearer to his law. No such law exists.

The several elements of a design may admit occasionally of scientific treatment by means of exact empirical formulæ—for example, the buoyancy, stability, and speed. But a formula or law does not exist for combining the above elements with strength, endurance, protection, and armament, and arriving at the best results. This has always been, is now, and in all probability will continue to be, a matter of opinion—or, rather, difference of opinion—and so let us leave it.

DIMENSIONS

Displacement is determined by the principal dimensions, length, breadth, and depth, and by the form of the lines. Each dimension is determined with respect to absolutely different things, and each one must be thought out carefully by itself, never forgetting at the same time certain empirical ratios with respect to each other that have been found to exist in successful ships of similar design.

DRAUGHT

This dimension is influenced chiefly by such practical considerations as the depths of harbors and docking accommodations. Although designed to operate normally from certain bases, it is plain that battleships should not be materially restricted in their actions to certain fixed ports. It is true that any well-devised battleship-building programme should be undertaken concurrently with a programme for increased depth of harbors, and size of docks, but the practical considerations of the great cost thus involved must always exert a strong influence toward moderate draught. Having in view these reasons, it would be well, at least until harbors and docks have been further enlarged, to restrict the normal load draught of our battleships to 30 ft., the deep load draught not to exceed 32 feet.

BEAM

The question of beam to which we now come is determined somewhat with regard to width of docks,[1] but more with regard to stability, since the position of the metacenter is determined chiefly by the beam, and the metacentric height is the most important consideration affecting the movements of a ship in a seaway. The position of the metacenter varies directly as the square of the beam, so that if we increase the beam, we materially increase metacentric height, initial stability, and the stiffness of the ship in a seaway. This stiffness should be ample to prevent a too great heel when turning, or when side compartments are flooded, but not so great as to impair the steadiness of the gun platform and render the motion of the ship jerky and unsteady.

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[1] It is limited, for the present, at least, by the 110-ft. width of the Panama Canal locks.

Exact formulæ for the influence of beam on speed do not exist, but model experiments seem to bear out the fact that on a given displacement for an increase of beam of, say, 5 per cent, the effective horse-power must be increased by the same percentage if the same speed is desired, and that if length be kept constant the ratio $\frac{B}{D}$ can be varied widely without any very appreciable effect on resistance.

LENGTH

This dimension is influenced more by the speed than by any other feature of the design. In order to obtain high speed it is absolutely necessary to have length. To give a concrete example of this, assume that we desire 24 knots speed from a 30,000-ton ship. With a 690-ft. length the speed could be obtained with about 40,000 horse-power. Keeping beam and draught constant, but shortening the length to 630 ft., there would be needed 50,000 horse-power, and at 570 ft. over 80,000 horse-power would be required; whereas, if we desire only 20-knots speed, it can be obtained on a 570-ft. length with but little more than 40,000 horse-power. Furthermore, not only will the shorter ship require much more horse-power for a given speed, but it affords less length for the installation of the increased horse-power, so that practically the length must be great enough to enable the necessary machinery to be installed.

On the other hand, by a too great increase in length we reach a point where the frictional resistance, due to increased wetted surface, is greater than the gain from reduced wave-making resistance, particularly at cruising speeds. Length is not favorable for maneuvering, increasing the resistance to turning. Length necessitates a serious increase in displacement, due to the greater weight of armor and hull for the same protection and same strength.[3] Greater length means greater target area, and incidentally there are but few dry docks that will accommodate great lengths.

DISPLACEMENT

Many other features must be given their relative weight, the chief of which are seaworthiness, freeboard, and type of hull fittings, but enough has been said to indicate the principal military and technical considerations influencing and limiting battleship displacement.

Passing over the more or less mechanical end of the calculations involved, it may be stated that, in the present state of the art of the naval architect and marine engineer, it is not possible to adequately fulfil these principal claims on less dimensions than 640 ft. for length, 96 ft. for beam, and 30 ft. for draught, with a consequent displacement of approximately 36,000 tons.

Thus, although we have restricted the number of turrets to five, and the number of guns to ten, confined our armor to vitals only, used only moderate speed, and employed every technical and engineering means to reduce displacement, we have arrived inevitably at a large ship. Moreover,

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[3] If the same percentage of side is to be protected without decreasing the thickness of armor, the weight of side armor will increase directly with the length. The increase in hull weight is due to the greater area of plating, this area increasing approximately as the square root of the length, and also to the greater thickness of plating which it is necessary to use in order to provide adequate strength to meet the bending moment, which increases roughly as the length.

y "smaller" ship, must be inferior
hip of greater displacement will
ure for harbors and docks, and the
ould not be commensurate with the
s incident to great displacement.

COST

rge and small battleships should properly
me" cost, but the cost of maintenance as
nts it should also include the cost incident
g facilities, and it has already been shown
uch a large expenditure as to materially
isplacement of capital ships. As regards first
y to indicate the practical relation on battle-
etween cost, displacement, and effective gun
ncreasing the cost one-half, and the displacement
produce a unit with double the effective gun fire.[1]
and more numerous units are constructed for the
with an effective gun fire equal to one-half that
ay expect to provide only three smaller vessels for
and the effective gun power of the two large ships
reater than that of the three smaller ships (*i.e.*, in pro-
Moreover, the cost per annum of manning and main-
umerous fleet will be materially greater. It may be
mated that this increased cost of maintenance of the
over that of the two larger ones will be less than 5 per
Assuming the life of a capital ship to be twenty years,
per cent more to man and maintain the more numerous
o to be observed that, although the cost per unit for "large"
greater, the risk of total loss is correspondingly smaller on
he better subdivision possible to provide on the larger ship,
ater distance from the skin of the ship at which it is possible
e boilers and magazines.

FIGHTING VALUE

y advantages of the larger units become greater and more accen-
when the fighting value of a fleet of units is considered. This is
ularly true when we compare fleets of equal cost. It has been shown
for a given expenditure of money it is possible to provide one-third
c gun power on larger vessels than on smaller vessels each of gun power
ivalent to one-half the larger vessels.

If the caliber of guns in the two fleets be assumed equal, then the larger hips possess a one-third greater numerical superiority. This would indicate that the fighting power of the large ships with relation to that of the small ships is in the proportion of

$$\left(\frac{4}{3}\right)^2 = \frac{16}{9} = 1.77$$

Furthermore, the destructive value of a fleet is determined not only by the fighting value of its units, but by the method of employing that fighting value. The principal factors in connection with the method of employing fighting value are (1) maneuver, and (2) fire control. Maneuver enables a fleet to gain that relative numerical superiority of guns required by the principle of concentration. The fewer number of units in the fleet of large ships allows a greater ease of maneuver on account of the handiness of a short line as compared with the clumsiness of a long one, apart from such matters as visibility of signals, etc. If it is argued that the smaller, and therefore more numerous, fleet possesses a larger power of combination, the answer is that in a naval battle it is not power of combination that we desire, but power of concentration.

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[1] Paper by Chief Constructor F. T. Bowles, U. S. Navy, 1902; also paper presented by Professor Welsh in the Spring of 1911, Society of Naval Architects and Marine Engineers. See also comparison of contemporary United States designs.

From the point of view of fire control, the big ship again has a great advantage. Assume three small ships fighting one large one. To anyone who has witnessed long-range target practice, and attempted to spot the fall of salvos, it is at once apparent how extremely difficult, if not indeed impossible, it would be to identify the salvos of the three smaller ships as they fall about the large one, whereas the fire control officer and spotter of the single large ship can concentrate their salvos on either one or two of the smaller ships, identifying unerringly each salvo. The advantage of the small ships due to the "dispersion of target" offered by them would be more than counterbalanced by the great handicap of being unable to identify their salvos.

CONCLUSION

Since the ultimate purpose in modern war is the disruption and destruction of the organized forces of the enemy, the purpose of our battleship fleet is neither the defense of our coast, the blockade of the enemy's fleet in his ports, the capture of seacoast forts, nor even the "command of the sea." Its mission—its sole mission—is battle, the complete and relentless destruction of the enemy's battle fleet. To this end it must possess at the outset and maintain by maneuver during battle that relative superiority which is the key of all decisive battles by land or by sea. This can be obtained most certainly, and at a much less cost per gun, by concentration of fighting power in large units.

It has been shown that the fulfilment of the present-day claims on the military and technical characteristics of battleship design imperatively demands a ship of large displacement. It has also been shown how each element of a design can be benefited by an increase of displacement. Apart, however, from this gain, the larger ship possesses certain inherent advantages over the smaller one that more than overweigh the disadvantages due to size:

Greater concentration of armament.

Better protection of buoyancy and stability by comparatively more minute subdivision.

Greater protection by armor, because the thickness of armor need not be increased with displacements, and the same area will protect a greater tonnage.

More economical propulsion.

Greater radius of action.

Greater sustained sea speed under all conditions of weather.

Greater efficiency per gun due to the wide separation of turrets, machinery, magazines, etc., also on account of the greater safeguards it is possible to provide on the large ship with regard to the supply of power, ammunition, and every other essential that serves the gun.

Moreover, it is only large displacement which makes it possible to provide that adequate protection against underwater attack which is becoming more and more necessary, and which cannot be provided with smaller displacements.

These are the reasons that demonstrate so convincingly the value of the larger ship, and that will force us inevitably to build larger and even larger units until such time as the improvement in submarine and aerial offense shall drive the present battleship type from the sea for ever.

—*The Engineer.*

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OUR SUPERB BATTLE-CRUISERS

By the courtesy of the Secretary of the Navy, we are enabled to publish the official drawing of the accepted design for our new battle-cruisers, the construction of a division of six of which was authorized last summer. It will be agreed that, without exaggeration, these stupendous warships, in their combination of size, speed, and power must be considered to be the most novel and sensational (if we may use the word) ships designed for any Navy since the day of the British *Dreadnought.* They have the length of the largest transatlantic liners, the speed of the fastest destroyers, and the gun power of a modern battleship. On one point only, that of armor protection, is information lacking. The *Scientific American* does not know exactly the thickness and distribution of this armor, and if we did we would not tell; for if there is one feature of warship design more than any other upon which the Naval Constructor is silent, it is that of the armor plan of new ships.

To come down to details, the new battle-cruisers are 850 feet between perpendiculars and 874 feet over all; their beam is 91 feet, and their draught is over thirty feet. Now 850 feet between perpendiculars is just 100 feet greater than the length between perpendiculars of the famous *Lusitania,* and, if we remember rightly, it is exactly equal to the length between perpendiculars of the Hamburg-American liner *Imperator.*

In view of these figures it is surprising and very significant to learn that the displacement of the battle-cruisers will be only 34,800 tons. This is several thousand tons less than the full-load displacement of the *Lusitania* and about 20,000 tons less than the full-load displacement of the *Imperator.*

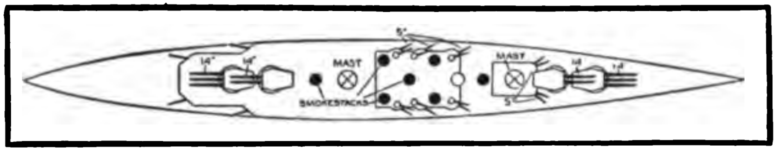
The apparent discrepancy is explained by the relatively modern beam, 91 feet, of the battle-cruisers, and the remarkable fineness of their model. The *Imperator* has 7 feet more beam and she carries this throughout several hundred feet of her mid-length. The battle-cruisers, on the other hand, fine away rapidly towards bow and stern, the entrance and the run of the vessels being as fine, if not finer, than that of a destroyer. Moreover, the midship section shows a decided dead rise and the round of the bilge is turned in with a large radius, differing in this respect greatly from the cross-section of the typical warship of big displacement.

In spite of the extreme refinement of the underwater model, in order to secure a contract speed of 35 knots, which is 5 knots faster than that of any existing British or German battle-cruiser, it has been necessary to

Scientific American. 1961

THE NEW UNITED STATES BATTLE-CRUISERS

LENGTH (OVER ALL), 874 FT. BEAM, 91 FT. DISPLACEMENT, 34,800 TONS. HORSE-POWER, 180,000. SPEED, 35 KNOTS. ARMAMENT: TEN 50-CAL., 14-IN. GUNS; TWENTY 50-CAL., 5-IN. GUNS FOUR 3-IN. ANTI-AIRCRAFT GUNS; EIGHT 21-IN. TORPEDO TUBES. COMPLEMENT, 1274



DECK PLAN 1962

install a boiler-and-engine plant of 180,000 horse-power. This is two-and-a-half times larger than the motive power of the *Lusitania*, which made 25 knots with 70,000 horse-power, and it is over twice the horse-power of the *Imperator*, which made 23 knots with 80,000 horse-power. Now those of our readers who make a study of these big ships, naval and mercantile, will be asking how in the world it is possible to get this amount of motive power inside a ship with such a refined model as these. They will remember that the engines and boilers of the *Lusitania*, for instance, took up approximately three-quarters of her floor space, extending from the stern to the bridge.

The solution of the problem is a demonstration of the remarkable advance which has taken place in marine engineering during the past decade. The *Lusitania* used the bulky Scotch boiler. She demanded a width of 18 feet on each side of the ship for her huge coal bunkers, of 7000 tons capacity, and her relatively slow-speed compound turbines demanded a large share of the tank top area for their installation. The battle-cruisers substitute the compact watertube boiler for the Scotch boiler; oil fuel, stored in the double bottom, takes the place of coal and the coal bunkers, thus permitting the whole width of the ship to be given up to the boiler plant; high-speed turbines direct-connected to generators will furnish current for driving motors placed directly upon the four propeller shafts, and, lastly, we shall see in these ships the novelty of the boiler-and-engine plant being located upon two decks.

If it were not for the use of oil fuel, watertube boilers, and the turbo-electric drive, it is certain that these wonderful ships could never have been designed, much less, built.

The electric drive has solved the problem of reconciling the demand for high speed of rotation in the steam turbine with the demand for relatively low speed of rotation of the propellers. To get the full efficiency of the turbine it is necessary that the speed of the blades in the turbine be high, but in large ships such as this, to obtain the best efficiency with the propellers, it is necessary to keep their speed of rotation down within certain limits. In the earlier turbine ships, when turbine and propeller were on the same shaft, the matter was compromised by running the turbine below its best economical speed and the propeller above its best economical speed. The problem has been solved of late years by the introduction of reduction gearing. Westinghouse of this country and Parsons abroad have secured good results with mechanical gearing, and the General Electric Company have obtained excellent results with their turbo-electric drive, as installed on the U. S. Collier *Jupiter*. It is their system which will be used on the new battle-cruisers.

The question of the type of gun (14-inch or 16-inch) to be mounted in the main battery of the new battle-cruisers has been decided in favor of the new 14-inch, 50-caliber gun, and ten of these will be mounted in four turrets, two of them carrying three guns and two of them two guns each, the number of guns and their method of emplacement being similar to that of the battleships *Nevada* and *Oklahoma*. The total energy, however, is considerably greater, the 50-caliber gun of the battle-cruisers developing 70,000 foot-tons of muzzle energy as against 65,000 foot-tons for the 45-caliber gun as mounted on the *Nevada*. This means that a broadside salvo from the battle-cruisers will have a total muzzle energy of 700,000 foot-tons, or sufficient to lift 1000 tons 700 feet into the air. Defense against torpedoes will be entrusted to a battery of twenty, 50-caliber, 5-inch guns, sixteen of which will be mounted amidships on the upper and superstructure decks. No less than eight torpedo tubes for firing the new 21-inch torpedo with a range of 10,000 yards will be emplaced, four of these being above water and four below.

The new ships, because of their great size, will naturally carry a large complement, greater indeed, than that of any ship afloat. The total number, including officers and men, will be 1274.

So far as appearances go, it must be admitted that these stupendous ships will be exceedingly handsome in appearance. Although their freeboard is ample for all conditions, except perhaps that of chasing the enemy at full speed in a head sea; they do not tower above the water to anything like the height of modern transatlantic liners like the *Aquitania* and *Imperator*, and hence they will look even longer than their great length. Their appearance will seem to justify the enormous speed, for ships of this size, of 35 knots. Thirty-five knots is over 40 land miles per hour, and, in view of their great length, fineness of model, and large horse-power, we believe there is every prospect of their making this speed when the Government trials take place. It will be noted that the upper, or spar deck, extends for fully three-quarters of the length of the ship, its after-end projecting beyond the muzzles of the aftermost 14-inch guns.

An excellent improvement is the placing of the forward mast immediately upon the conning tower, thus preventing the possibility of its being brought down by a shell bursting between decks below it—a liability to which the mainmast would seem to be exposed. Another novelty is the provision of a lower, or secondary control station for both fire and ship control, below the fighting top on each mast.

The possession of a division of six of these ships, assisted by the two divisions of 7000 tons 35-knot scouts which are to be built, should render our fleet supreme in the field of scouting, or information. They will be able to drive in or break through any enemy screen, and because of their great speed they can accept or refuse battle as the conditions demand. The combination of great speed and heavy batteries will make them the terror of destroyer flotillas, and their speed and quick maneuvering power should render them practically safe against the torpedo.

—*Scientific American.*

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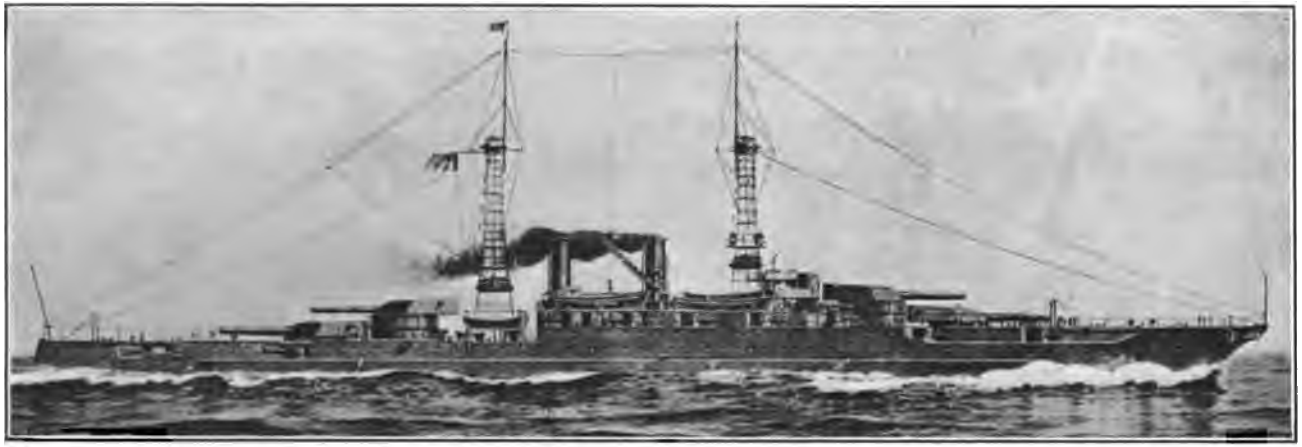
THE "COLORADO" CLASS OF BATTLESHIPS

The First of Our Battleships to Mount the 16-inch Gun

The "Colorado" class of battleships, of which there are four: *Colorado, Maryland, Washington,* and *West Virginia,* are the first four of the ten battleships authorized under the great bill for the upbuilding of our Navy, which recently was passed by Congress.

As will be seen from our illustration, the outboard profile, or broadside view, shows them to be very similar in appearance to the class which preceded them. The main battery is mounted in four turrets; but in place of twelve 14-inch guns in four three-gun turrets, the "Colorado" class will mount eight 16-inch guns in four two-gun turrets, the two inner turrets

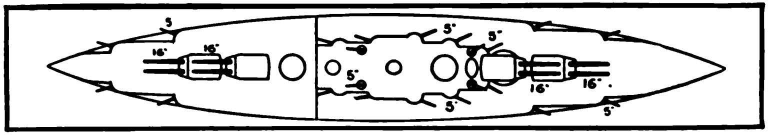


Scientific American.

1963

THE NEW "COLORADO" CLASS OF BATTLESHIPS

LENGTH (OVER ALL), 624 FT. DISPLACEMENT, 32,800 TONS. SPEED, 21 KNOTS. ARMOR: BELT, 14 IN., TURRETS, 18 IN. ARMAMENT: EIGHT 45-CAL., 16-IN. GUNS; TWENTY-TWO 5-IN. GUNS; FOUR 3-IN. ANTI-AIRCRAFT GUNS; TWO 21-IN. TORPEDO TUBES. COMPLEMENT, 1022.



DECK PLAN

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have been under fire in the present war, have been incorporated. The main belt will be about 14 inches in thickness and the turret armor will be proportionately heavy, with a maximum thickness of 18 inches provided on the port plates.

Apart from the 16-inch gun, the most interesting feature of these ships is their motive power. They will be equipped entirely with oil-burning boilers and will be driven by General Electric turbines, direct-connected to generators whose output will be led by cables to motors on the propeller shafts. This is the system which has been tried out with conspicuous success on the U. S. Collier *Jupiter*. The contract calls for a shaft horsepower of 26,800, which should give these ships a speed of 21 knots. The *Colorado* will carry two 21-inch submerged torpedo tubes.

—*Scientific American.*

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THE PRIVATELY OWNED NAVAL SCOUT

Much interest has been taken in the efforts to establish co-operation among boat clubs and owners of small power boats, as well as between such parties and the Government, to the end that an efficient reserve of privately owned vessels may be quickly available for the use of the Navy. Of the various steps taken in this direction, certainly none is of more promise than the action of the Navy Department itself in standardizing such vessels by adopting official plans for several types. As the result of the submission to the department of competitive plans for scout cruisers of two sizes—45 and 66 feet—an award has been made in each class and construction begun of single vessels from the accepted drawings.

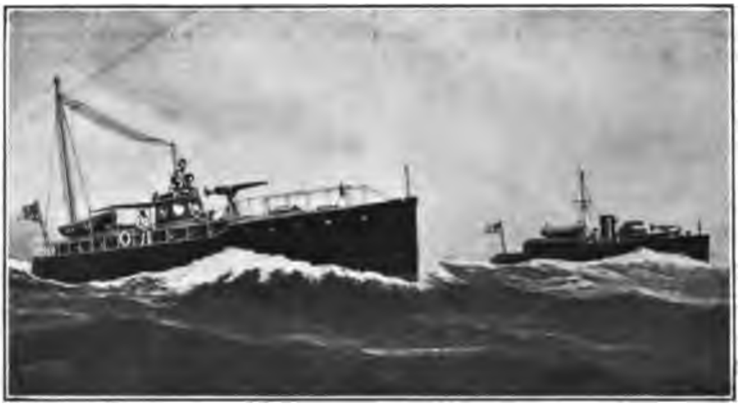

FIG. 1. 1966

THE TWO TYPES OF COMBINATION PLEASURE AND WAR CRAFT, AS STANDARDIZED BY THE NAVY DEPARTMENT

The prime consideration brought to the attention of the designers of these craft was the fact that when not required by the Navy the boats will be used by the owners essentially as pleasure yachts. They must, therefore, embody a combination of the desirable features of express cruiser and motor scout-boat, with ample living quarters and deck space, and at a cost not too much in excess of that of normal pleasure vessels of comparable dimensions. They must be capable of a sustained speed of 30 miles per hour for four hours and 26 miles per hour in a moderate sea for six hours. They must have space for a full supply of fuel, stores and ammunition, and present a good point of vantage for the mounting of a rapid-fire gun.

The larger of the two types now standardized by the action of the Navy Department is 66 feet overall by 13½ feet beam, with a draught of 4¼ feet. The boat has a hull of the hollow bottom, wave-collecting type, with raised deck forward, and a pronounced flare to her bow.

The machinery is placed amidships, dividing the living quarters into two distinct suites. The main saloon is in the after-deck house, being 8 feet long and extending clear across the boat. The forward saloon is less commodious, but in connection with the forecastle affords ample accommodation for the small crew required, whether on a pleasure or on a war footing.

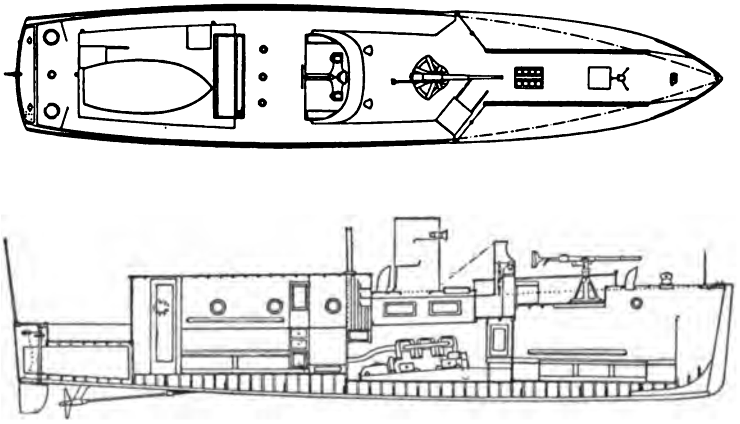

FIG. 2. 1966

PLAN VIEW AND SIDE ELEVATION OF THE 45-FOOT NAVAL SCOUT

The power plant consists of two 12-cylinder motors of about 400 horse power each, with independent motors for lighting and wireless systems. An extremely large fuel capacity is demanded by the great radius of action —500 miles at 25 miles per hour—and is secured by means of three 600-gallon tanks amidships, behind the engine-room, and a reserve tank of 300 gallons at the extreme stern of the vessel.

The aerials for the radio outfit are carried from a mast stepped well aft to the conning tower amidships over the engines. The latter serves also as a pedestal for the searchlights. Just forward is mounted the 3-pounder rapid-fire gun.

Similar to the larger boat in its general features is the 45-footer. It has, however, a round bottom, like the vessels of the patrol squadron that have given such good account of themselves during the past season. The beam is 10 feet and the draught 3 feet. As before, the engine room is about amidships; forward are the quarters of the crew, aft the owner's stateroom, which in war service automatically becomes the officers' quarters, accommodating four persons.

Two 6-cylinder motors of 125 horse-power each are provided. Four fuel tanks, with a capacity aggregating 500 gallons, are located beneath the after deck, and make the operating radius equal to that of the 66-foot vessel.

The one notable deficiency of the smaller boat lies in the absence of wireless equipment, there being insufficient space in which to string the aerials. The gun, a 1-pounder, is mounted forward of the conning tower as in the 66-footer.

Construction of both types of these vessels is extremely strong, with adequate ventilation throughout the ship, and steel bulkheads dividing the interior space into water-tight compartments. Altogether an admirable boat is provided for the man who wishes to cruise for pleasure, to take an occasional hand in the war-game, and, when occasion presents itself, to be of real service to his country.—*Scientific American.*

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THE CAPTURED GERMAN MINE-LAYING SUBMARINE[1]

In our issue of August 19, 1916, we presented photographs of the captured German *U C-5*, a mine-laying submarine which was taken by a British destroyer off the east coast of England last April.

By the courtesy of the British Admiralty, we are now enabled to present the official drawing, showing in considerable detail the construction and interior arrangements of this little craft. The *U C-5* is diminutive, if we compare her with the latest submarines of from 800 to 2000 tons displacement; but, as may be seen from the engraving, she is big enough to carry a dozen mines in her launching tubes, and, indeed, is credited by the British with having made as many as a score of trips from her base at Zeebrugge, on the Belgium coast. Her dimensions are given as about 110 feet length, 11 feet beam, and 200 tons displacement.

The mines are carried in the forward part of the boat in six vertical tubes, extending clear from the top to the bottom. At the deck, each mine tube is covered by a grating, and its lower end is open to the sea. The tubes are inclined aft at about 25° from the vertical—this to insure that a mine will leave the ship in a direction opposite to that in which the boat is traveling. Each mine is held above its anchoring weight by four sets of angle-irons, and in these there are recesses which are engaged by plungers in the wall of the tube, which serve to hold the mine in place when it is not in use. There are two mines in each tube, one carried above the other.

When it is desired to drop a mine, the plungers of the lower mine are withdrawn by means of connections from the conning tower, and it drops through the bottom of the boat. The upper mine can be released in the same way.

The whole mechanism as thus dropped into the sea, consists of a heavy bottom disk, forming the mine anchor, and above this a spherical case containing the high explosive. These two parts are held in their relative positions by the four hinged angle-irons above referred to. When the mine strikes the bottom, the four arms are thrown out into a horizontal position by means of springs. The mine proper contains a relay device, which insures that the mine shall not become buoyant until sometime after it has left the launching tube. The object of this is to make sure

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[1] See JOURNAL U. S. ARTILLERY for September-October, 1916, for other illustrations of this ship.

dimensions. They must be capable of a
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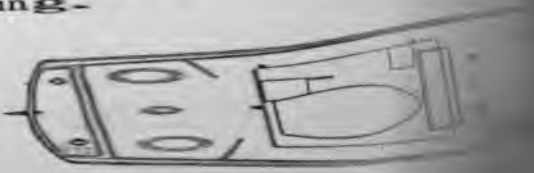

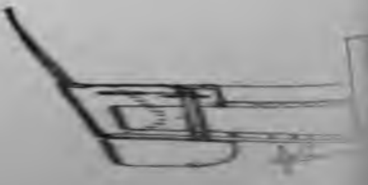

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essed air. Aft of the tubes is a heavy bulk-
artment largely given up to storage batteries.
are the ballast tanks and the working chamber,
immediately below the conning tower. In the
70 storage batteries with living quarters above.
d is the engine room and the aftermost compartment
tank.
t with a double skin and it has reserve buoyancy tanks
ight sheet-steel deck is built above the boat, and beneath
tor silencers, sounding machine and other gear. The oil
in the double bottom. There is evidence that the boat was
sections to enable it to be carried by rail, canal or otherwise.
—*Scientific American.*

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SLIDE-RULE FOR FINDING RANGE TO CLEAR CREST

By Second Lieutenant J. Noble Kennedy, R.G.A.

This slide rule is designed to indicate the minimum elevation at which the trajectory of a 60-pdr. shell will clear intervening crests of various heights with given angles of sight.

I venture to suggest that, in a moving battle, when new battery positions would frequently be chosen, this slide rule would assist the battery commander to ensure that his prospective targets were not in "dead ground," by performing the function of the oscillating sight as described in Pamphlet of 60-pdr. Gun, 1916 (p. 26).

The slide rule can, of course, be adapted for any nature of gun by suitable graduation of the range slide. Its accuracy could be increased by graduation in half degrees and 500's of yards. It might be made more useful by attaching to the back some simple form of clinometer by means of which angles to crests could be measured in the field.

Description

There are three scales:

The upper scale (fixed) is graduated at equal intervals in degrees. On this is set the angle to the crest (measured by map, director, or otherwise).

The middle scale (movable) is similarly graduated in degrees. On this is set the angle of sight to the target.

The lower scale (movable) is graduated in thousands of yards of range, the intervals being proportionate to the equivalent angular elevations as shown in range table.

OPERATION

The method of setting the slide rule is as follows:

Put the range to the crest under the zero of the upper scale, using cursor.

Put the angle of sight under the crest angle.

Read the minimum range to clear the crest under the zero of the angle-of-sight scale, using cursor.

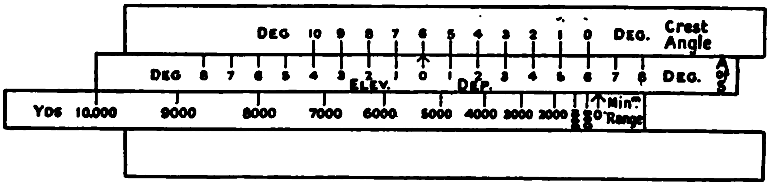

FIG. 1.

EXAMPLE

Range to crest	500
Angle to crest	5°
Angle of sight	1° depression

Using cursor, slide range scale along until 500 is under the zero of the upper scale. Slide middle scale until 1° depression is under the 5 of the upper scale. Move cursor over the zero of the middle scale and read off the range required which is, say, 5300.

NOTE.—I have heard of similar slide rules being in use but I do not think they make allowance for the range to the crest, without which they would not be accurate enough to be useful.

This slide rule in its original form was made at the Royal Military Academy in collaboration with Lieut. A. Jennings, R.H.A., to whom my acknowledgements are due.—*J.N.K.*—*Journal of the Royal Artillery.*

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WIND DIAL CORRECTOR

By Second Lieutenant J. NOBLE KENNEDY, R.G.A.

I suggest that this wind dial corrector will provide a simpler and more accurate method than the present one of determining the corrections necessary on account of wind.

The present system is to find:

a. The component velocity along the line of fire (for use on B.C. slide rule), by means of the "fall of shot diagram."

b. The deflection, by means of the "wind graph."

The drawbacks to this method are:

a. That a calculation is necessary to obtain the direction of the wind in relation to the line of fire—although simple, this seems, in practice, to present some difficulty; another calculation is introduced owing to the fact that the "wind graph" gives deflection for 10 f.s. only.

b. That two separate operations must be carried out to arrive at the information required, and the whole method is too complicated.

The method proposed involves no calculaton and is purely mechanical. It has been found much easier to explain to N.C.O's.

The table for conversion of "feet per second" to "minutes deflection" could be amplified and made more accurate. I have had no facilities for doing this myself. The table given is for 60-pdr. gun.

Operation

Set dial so that true bearing of target coincides with "line of fire" at the top.

Note the radial line representing true bearing of wind, and the point in that line representing its velocity in f.s.

WIND DIAL CORRECTOR.

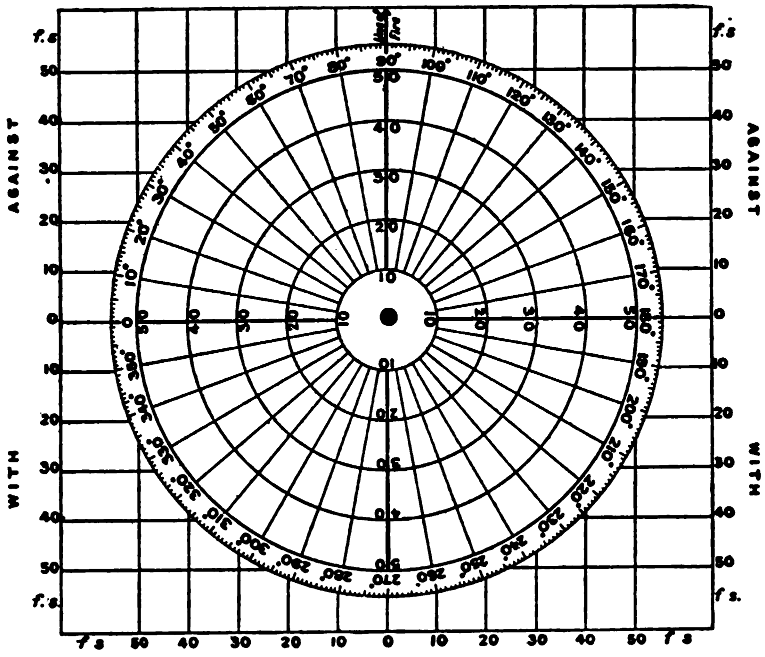

Fig. 1.

Read off components along and at right angles to "line of fire."

Use first component for B.C. slide rule.

Convert second component to deflection by means of table.

EXAMPLE

True bearing of target 60°. Range 8000.

Wind 40 f.s. at 180°.

Component for B.C. slide rule: 20 f.s. with.

Component at right angles to L.O.F.: 35 f.s. right, which by table = (say) 42′ right (between 36′ and 48′).

Table for Conversion of F.S. to Deflection.

Range	10 f.s.	20 f.s.	30 f.s.	40 f.s.	50 f.s.
	'	'	'	'	'
1000	--	--	--	5	8
2000	--	5	9	12	15
3000	5	10	15	20	25
4000	6	12	18	24	30
5000	8	16	25	32	40
6000	10	20	30	40	50
7000	10	22	34	45	55
8000	12	24	36	48	60
9000	13	26	39	52	65
10000	14	28	42	56	70

M.P.H.	F.S.
35	50
28	40
20	30
14	20
7	10

—*Journal of the Royal Artillery.*

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AN AEROPLANE MACHINE GUN THAT FIRES BETWEEN THE REVOLVING PROPELLER BLADES

It seems a mechanical anomaly that many of the battleplanes flying over the fighting forces of Europe should be equipped with machine guns that fire through the path of the revolving propeller. Yet this condition has been brought about in the development of the fast and highly-flexible battleplanes, such as the single-seater Morane of the Allies and the single-seater Fokker of the Germans.

High speed and flexibility of control are the two main requisites of a battleplane, for the victory in an aerial duel rests with the aviator having the fastest and most flexible mount, the skill of the adversaries being equal. Hence in the development of the battleplane is has been found necessary to eliminate the gunner or *tireur* whose duty was to fire the machine gun while the pilot devoted his attention to the control levers of the craft, bringing into being the single-seater fighting machine whose pilot, aside from his usual responsibilities, has to shoulder the additional duties of gunner.

In the present-day single-seater battleplane the machine gun is usually placed in front of the pilot, above the engine cowl. Since the pilot is unable to remove his hands from the control levers for any considerable length of time, the sighting of the gun is accomplished by alining the entire aeroplane with the target, the gun being rigidly attached to the cowl. In certain of the French machines the gun is fired continuously through the path of the revolving propeller blades, no attempt being made to select such times for the firing when the blades are not in the path of fire. The portion of each propeller blade coming in direct line with the muzzle of the gun is sufficiently armored so that the bullets that strike are deflected without causing any damage, and it is estimated that under no circumstance does the wastage of fire exceed 30 per cent.

In designing their premier fighting machine, the Fokker, the Germans have endeavored to improve upon the French machines by eliminating the wastage of ammunition, not so much because of the extravagance of the wastage but because an aeroplane can only carry a limited amount of ammunition, each round of which must be made to count in a prolonged engagement. The result is found in the machine gun of the Fokker air-craft, which is automatically fired between the revolving propeller blades and without wastage of ammunition. While the majority of the Fokkers are single-seaters, by way of exception there exist a few two-seater machines equipped with a couple of machine guns, one of which is fired through the propeller while the other is mounted in the rear to give a clear sweep of the skies.

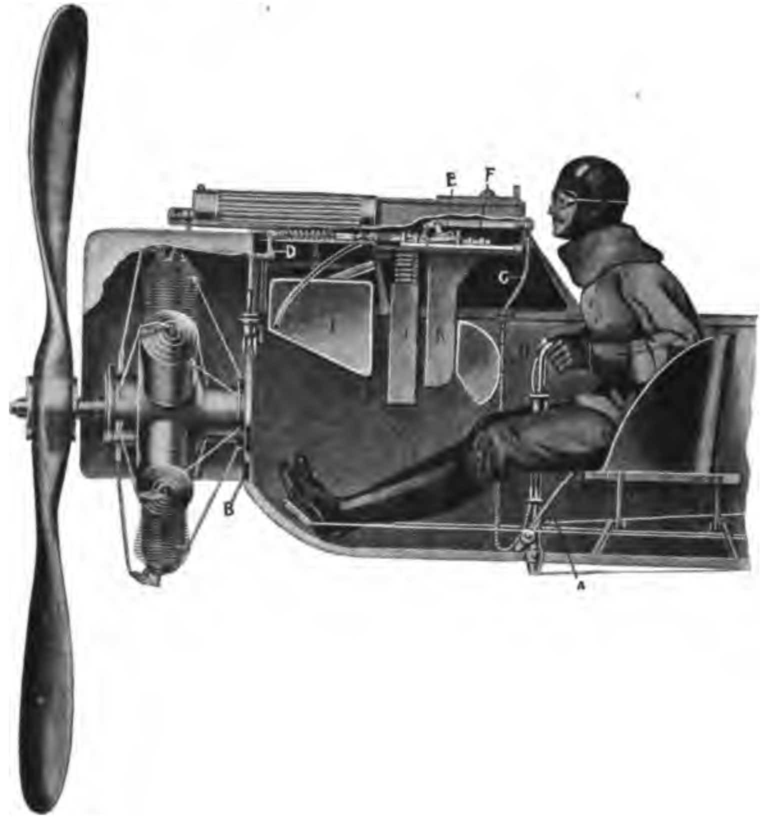

FIG. 1. 1970

BY MEANS OF THIS ARRANGEMENT OF A CAM ON THE ROTARY ENGINE SHAFT AND A TRANSMISSION SYSTEM OF LEVERS AND SPRINGS, THE MACHINE GUN OF A FOKKER BATTLEPLANE FIRES BETWEEN THE REVOLVING PROPELLER BLADES

It will be noted by studying the accompanying illustration that the control mechanism of a Fokker is centered in a single post fitted with handle bars similar to those of a bicycle, supplemented by a rudder bar operated by the feet of the pilot. The elevation and depression of the horizontal rudder is effected by the backward and forward movement of the steering column, while the lateral stability of the aeroplane is maintained by the side to side movement of the post by means of the pilot's knees acting on an adjustable sliding sleeve. The seat is adjusted both horizontally and vertically.

The first move of the Fokker pilot after engaging with an enemy airman is to settle on a certain plane of flight and then lock the elevator control by means of lever *A*, so that he can then steer to right or left by the action of his feet on the rudder bar and maintain lateral balance by moving the control post with his knees; but he must continue the flight in the same plane until the elevator is again freed. This procedure permits the airman to use his hands, since they are no longer required on the handle bars.

The machine gun of the Fokker is of the Maxim type and is immovably affixed above the engine cowl and slightly to the right, so that its line of fire passes through the path of the revolving propeller in front. In sighting his gun the pilot, as previously stated, maneuvers his aeroplane until the sights register on the target. This task calls for a high degree of skill, for both the firing medium and the target are mobile, while the steering of an aeroplane is accomplished by relatively slow movements of considerable amplitude.

Instead of the machine gun being fired by pulling the trigger, as in usual practice, the trigger is operated by a cam and transmission mechanism under the control of the pilot. On the revolving shaft of the rotary engine is a disk carrying a slight bulge at one point whose relation is at right angles to that of either propeller blade. The disk is indicated at *B*, while upon it rests a small wheel *C*, which receives the reciprocating movement brought about by the use of the cam member. The reciprocating movement is transmitted by a system of levers and springs, *D*, finally terminating in the piece *E*, which is hinged as shown. Normally, when the gun is not firing, the piece *E* is raised so that the reciprocating movement ends with it; but at the moment the pilot is ready to fire the gun he presses a smaller lever, *H*, fixed in the center of the steering bar control, which, by means of the bowden wire *G*, causes the piece *E* to be brought down in line with, and to act upon, piece *F*. The latter acts directly upon the trigger of the gun.

The action of the firing mechanism is to pull the trigger of the gun once for every revolution of the engine and propeller, at the moment when neither of the two propeller blades is in the line of fire, in spite of the high rate of revolution of the propeller which normally reaches some 1200 revolutions per minute or 20 revolutions per second. Since the average machine gun fires anywhere from 400 to 600 rounds per minute, or 6 to 10 per second, the opportunity to fire 20 times each second is ample for the proper functioning of the gun when the engine is turning over at the usual speed. The cartridges are fed into the gun from the belt magazine *J*, the empty shells are ejected through the tube *I* which passes through the wall of the fuselage, while the empty belts are deposited in the container *K*.

—*Scientific American.*

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ARMORED AUTOMOBILES—A WAR MACHINE THAT HAS UNDERGONE MANY CHANGES

It is safe to say that there is not an appliance used in warfare that has not undergone radical revision and improvement since the beginning of the European conflict, partly as a result of experience gained, and partly of necessity to meet the ever changing conditions that develop so rapidly in every branch of service; and among these the armored car has been the subject of particularly sensational development. This was to be expected, for this is the first time that the automobile has been called into actual service by armies in the field, and previously it can hardly be said that the motor vehicle had been very seriously considered as other than for the transportation of supplies.

Soon after the invading armies had penetrated Belgian territory rather exaggerated stories began to appear telling of the doings of the automobile in rapid forays conducted by both the Belgians and the Germans, for which purpose it was found extremely useful; but these cars were crude and hastily extemporized affairs, made by mounting a few steel plates on an ordinary pleasure vehicle in such a way as to afford a partial protection to the occupants of the car, and to the vital parts of the mechanism. Notwithstanding their evident imperfections the value of an armored automobile as a fighting machine in open country was quickly recognized, and a host of improved designs soon appeared on the scene, all of which not only provided more elaborate and effective protection for the occupants, but greater offensive power than was possible in the first make-shifts, for, instead of a few men armed with the ordinary military rifle, accommodations were arranged for machine guns, and frequently, also, for one of the smaller sizes of rapid fire guns, which were sometimes mounted in small revolving turrets that made it possible to fire them in any direction.

Many are the tales that have come to us of the successes of fighting cars of this description, in scouting expeditions, in attacks against outposts and surprise demonstrations leading up to attacks in force; but when the advance of the central powers was checked, and both sides "dug in," making the situation one of mutual siege, the armored car apparently disappeared, as it was not powerful enough to meet the heavy concentrated fire then to be met, and, moreover, with the destruction of everything resembling a road in the neighborhood of the fighting lines, the light armored automobile was put out of the running, as its ability to negotiate rough ground is decidedly limited, and it could by no means surmount shell craters, much less jump trenches, and for a time it looked as if its course had been run.

On the Eastern front, however, the operations were of a more open character, and soon we heard of the excellent service the armored car was doing there, where in some cases Russian cars broke through the opposing lines, and, opening an attack from the rear, contributed largely to important successes. Then came the Egyptian campaign, and here again, in open country, the armored automobile played an important and valuable part in breaking up scattered bands of opponents, maintaining telegraph lines and carrying dispatches through long stretches of hostile country.

More recently, one of the most sensational developments of the war was disclosed by the unexpected advent of the British Land Ships, as they are officially rated, but more popularly known as the "tanks," and thus was the armored car reincarnated in a surprising, but vastly more powerful and effective form, for it is not only capable of being operated over what has heretofore been considered impossible surfaces, but it is also proof against the attacks of anything short of powerful field guns, and is itself armed with heavier and more efficient weapons than any of its more agile predecessors.

The first reports of the tanks were of such a fantastic nature as to raise doubts of their veracity, for war correspondents, guided only by the camp gossip that filtered through devious channels, vied with each other in drawing verbal pictures of the new monster as a mechanical Behemoth, an Ichthyosaurus, or a Diplodocus; but for once these stories proved to be not so far from the mark as too often happens when writers for the daily press fall foul of a technical subject, for the tank is like unto nothing heretofore seen on wheels.

[Our frontispiece] shows a tank in actual field work, sliding serenely over a shell crater, and it will be seen that it consists of a small portable fort of steel that is invulnerable against any weapon usually found in advanced positions. This is provided with a sponson on either side containing a powerful rapid-fire gun, so mounted behind movable shields that it can cover quite an extensive field of fire. Probably the tank also carries several ordinary machine guns, although the photograph does not show them, and no details of the interior arrangements have been so far disclosed. This fort is mounted upon two endless corduroy belt tracks, one being disposed longitudinally on either side, and at the rear are large flanged steering wheels. At the forward end the track is carried upward at an angle, and this enables the machine to lift itself out of shell craters and similar depressions, while the balance of the outfit is said to be so adjusted that it will span any ordinary trench before the front end drops materially from the horizontal. The tank shown in the picture appears somewhat dilapidated, but while some of the markings may be due to dirt and the effects of gunfire, most of the varigated effects are the result of the system of "protective painting" which has been adopted, for all of the tanks are irregularly painted in browns, greens and yellows that harmonize with the lansdcape and make them difficult of detection at a short distance. This method of deceptive coloring, by the way, is by no means new, but has been extensively applied to field guns and other exposed objects in the field.

While the tanks are undoubtedly powered by large engines, their speed is very slow, averaging probably not over 1000 yards an hour; and this is but reasonable, for no vehicle could be expected to traverse a region torn into shell craters, and intersected by trenches, much faster than this. It is safe to say that, even if the machine were capable of greater speed, and could withstand the shocks incident to such running, its occupants could not, and still conduct the operations that are expected of them.

The powers of destruction attributed to the tanks are astonishing, and it is claimed that not only do forest trees offer no obstacle to their progress, but that their impact easily breaks down large tree trunks, when the machine rides unobstructed over the stumps. Masonry buildings of considerable size suffer the same fate, and they have several times been used to oust concealed riflemen entrenched in such structures.

A few short extracts from English papers relating to the tanks may be appropriate. The London *Times* quotes an officer as saying: "huge shapeless bulks, resembling nothing else that was ever seen on earth, which wandered hither and thither like some vast antediluvian brutes which Nature had made and forgotten.

"I watched the great things maneuver about the field, grotesque and unspeakable; and at each new antic which they performed, each new capacity which they developed, one could do nothing but sit down and laugh till one's sides ached. Were they only a preposterous joke or were they a serious contribution to modern warfare? * * *

"Of course, they are only an experiment; but on their first day they justified themselves completely. In one short hour they did more military service, killed more enemy in uniform, and had a greater influence on the war than all the Zeppelins have ever done."

It remains to be seen what the Germans will devise to checkmate these surprising machines.

What it is like inside a tank when in action, is suggested by the following extract from the diary of one of the crew, which appears in *The Motorcycle* (London):

"Monday.—Out in a fog. Completely at sea for first part of day, traveling at rate of 1000 yards per hour. Furious gun fire and ceaseless racket of machine guns. Enemy attack. Enough lead to smother us. Came through unscathed. Went blindly at foe. Terrible crash and ceaseless jolting. Up and down like a switchback. Dashed into a party of enemy, and crushed them under machine.

"Tuesday.—Out in abominable weather. Gun fire all the time. Vicious rattling on our metal hide. Machine guns everywhere; passed through without a scratch. Seemed to run into an earthquake. Nothing serious; only an enemy trench. Suddenly everything seemed to go wrong. Could not make the old thing move as much as half an inch. Stranded! Enemy thought we were done for and closed in with great glee; came right up to us. Still no sign of life; then sudden recovery. We opened fire; enemy went down like ninepins. Ship gave sudden lurch, then on as fast as we could. Enemy had not time to get clear. We knocked them over, and they were crushed underneath.

"Wednesday.—Had weirdest experience imaginable just as we were well under way. There was a sudden upheavel. "Tank" seemed to be lifted from the ground and tossed sky high. Felt sure it was all over. Terrible jar back on land again. Little the worse. Enemy had sprung a mine under us. Went forward at full speed."

The latest tank story that has appeared is a report in the daily papers of some wonderful machines that the Germans are said to be using in Roumania. These cars, we are told, have wheels shod with solid rubber tires a foot wide, and are capable of a speed of twenty-five miles an hour, which enables them to scout ahead of cavalry. On its face this story is misleading, for the machine described is not in any sense a "tank," but merely a variety of the orinary armored car of two years ago, although with possibly some minor improvements. Twelve-inch solid rubber-tired wheels can be seen on motor trucks daily in the streets of any American city, and such wheels would not enable the cars to traverse a country riddled with shell holes, much less trenches. Moreover, the speed claimed, while possible on many ordinary roads, would be absolutely impossible across country, for reasons already stated when speaking of the British creations. The entire story is apparently merely the conception of a poorly informed correspondent seeking a sensation.

The origin of the tanks has been much discussed, and many people have laid claim to originating the idea, and making suggestions. Obviously, the general suggestion came from tractors with similar propelling devices that are familiar in some sections of this country, many of which have been sent abroad during the past two years. That, however, is but one element in the design, and much ingenuity has been displayed in the combination and adaptation of apparently necessary features. To inquiries by the English public a Government official in Parliament has given credit to about a dozen people as having had a hand in producing the tanks, but no intimation was given as to what each one contributed.

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—*Scientific American Supplement.*

Short Notes

Effect of Shell Fire.—Far too few details as to the effect of modern shell fire on modern ships are as yet available for it to be safe to draw sweeping deductions. But when it is remembered that the bad light made it necessary to engage at a range which this war has taught us to consider only moderate it seems astonishing that the battle-cruisers should have come through such severe punishment with such insignificant injuries. One hears of a ship receiving over 50 hits of 11- and 12-inch shell without losing a knot of speed, one-tenth of her complement, or having one-quarter of her guns out of action—as an actual fact, needing no essential repairs to make her just as fit for fighting at the end as she was at the beginning of the action, and suffering no damages that very few weeks in dockyard cannot put right again.

This is a thing that should perhaps make one cautious in believing every enemy ship that was for any time under effective fire must be virtually destroyed, or shot to pieces. But it must be remembered that all through the action the British were using guns of far heavier caliber and, consequently, throwing far more destructive shells, than were the Germans. From 3:45 till 6 o'clock, Sir David Beatty's force was firing first four, then three broadsides of 13.5's and four broadsides of 15-inch guns. Only one of his ships was armed with 12-inch. We can take it as certain also that in the short time that the Grand Fleet was engaged, it would be the 15-inch and 13.5 gun ships that were principally in action. Where, therefore, there is reliable evidence of these ships having brought enemy vessels under a succession of salvos, it seems reasonable to suppose that he must have suffered, hit for hit, far more heavily than we did.

—*Proceedings of the U. S. Naval Institute.*

Anti-aircraft Gun for U. S. Navy.—An anti-aircraft gun, the first to be used by the United States Navy, will supplement the armament of the entire battleship fleet and a number of designated cruisers, according to an announcement made in Washington on July 17th. The battleships *Pennsylvania* and *Nevada* already have been equipped with these guns, and eighteen other ships and cruisers are to be fitted out as rapidly as they are available for navy yard work. The new defense weapon is the result of a three-year experiment by the Navy experts of the Bureau of Ordnance. It consists of a machine rifle about fifty calibers long and capable of hurling a three-inch shell 27,000 feet into the air at an angle of ninety degrees and can deliver its charge at rapid fire rate. Two of these guns are to be placed on each vessel. They will be riveted fore and aft on the rear stands of the gun turrets so as to give them the best possible firing radius. In this manner they can be swung into position for firing in all directions. On the boats mounting the old type of turret they will be placed on the boat stands or in the most available location. Naval experts, under the direction of Rear Admiral Joseph Strauss, Chief of the Bureau of Ordnance, have worked three years in turning out the gun. In its development the department has been forced to discard several types. The design of the gun to be used is credited particularly to the officers and experts connected with the bureau, among them being Commander G. R. Marvell, Commander A. L. Norton, retired, and Commander C. B. McVay, U. S. N., assistant to the bureau, who has played a prominent part in its development. With regard to the availability of the gun, Commander McVay has stated that it was easily constructed, and in an urgent case he had no doubt it would be possible to equip the land forces of the country with a sufficient number of the guns. For the present their use will be confined to the navy.

—*Journal of the Military Service Institution.*

Notices

The Journal of the Royal Artillery should have been credited with the reprint entitled "Notes on High Angle Fire" appearing on page 354 of the JOURNAL U. S. ARTILLERY for November-December, 1916.

The *Proceedings of the U. S. Naval Institute* should have been credited with the reprint entitled "The *Emden-Sydney* Engagement" appearing on page 375 of the JOURNAL U. S. ARTILLERY for November-December, 1916.

Attention is invited to the advertisement of Mr. Chas. R. Hoe, Jr., page xxvii of the Advertising Section. The address should be 84 William Street instead of 80 Maiden Lane.

The *Schweizerische Monatschrift für Offiziere aller Waffen* which was founded over thirty-eight years ago by Colonel Hungerbühler, the Swiss authority on military affairs, and which suffered greatly through his death, is for the year 1917 in other hands.

Colonel Feldmann is now in charge. The name of the new editor offers complete guarantee that this important and widely circulated periodical will, as heretofore, meet the demands which might be expected from a military journal.

The periodical will be published, as formerly, by Huber & Co., Frauenfeld, Switzerland.

The arrangement for club rates existing between the Proceedings U. S. Naval Institute and the Journal U. S. Artillery has been terminated by mutual agreement.

BOOK REVIEWS

Gallipoli. By John Masefield. New York: The Macmillan Co., 64 Fifth Avenue. 5½" x 7¾". 245 pp. 12 il. 3 maps. 1916. Cloth. Price, $1.25.

The author has had a varied experience in the field of literature covering prose, poetry, and the drama. From extensive wanderings he has acquired the versatile style of the world-traveled writer. Whether or not he participated in the operations against the Dardanelles, either in a military capacity or as a correspondent, cannot be determined from the text. It is not at all impossible for the book to have been written by a person who had never been near Gallipoli, even though its description of the terrain is quite accurate, and the horrors of war portrayed by a soul that seems to revel in picturing tragedy.

He states that the work was first initiated to answer the many questions put to him during a short visit to America, by people who asked "* * * why that attempt had been made, why it had been made in that particular manner, why other courses had not been taken." Later, in viewing the many phases of these operations, he began to consider the campaign "not as a tragedy, not as a mistake, but as a great human effort, which came, more than once, very near to triumph, achieved the impossible many times, and failed, in the end, as many great deeds of arms have failed, from something which had nothing to do with arms nor with the men who bore them."

The first chapter presents a brief but quite picturesque and accurate description of the Gallipoli Peninsula, but the picture is that of the emotional artist, not that of the military historian describing terrain for its tactical and strategical effect. Unfortunately the small maps included in the work are reproductions of newspaper sketches. It would have been much better had the author used one of the several excellent orographical or topographical maps published by the English Government.

The naval operations are touched upon too briefly, especially as these are the more valuable and instructive phases of the campaign. The omission of a more detailed history of these maneuvers detracts greatly from the value of the work. The several reasons which prompted England to initiate this campaign, and with which students of the Dardanelles are familiar, are given, but the vital happenings in the Admiralty and War Council, and the parts played by Churchill and Asquith, are ignored and the value of the work as a historical narrative lessened to that extent. Then, too, the author is influenced by his knowledge of after events and confuses some of his data. When he speaks of the possibility of "heavy howitzers" sinking warships while in the channel and of airplanes and seaplanes observing shots—the Turks had no heavy howitzers until some time after March 18, and the seaplanes with the mother ship *Ark Royal* were few in number and most ineffective in reporting on indirect fire during the earlier naval activities.

The final defeat of the Allied Fleet on March 18 is referred to in a few lines and the author mistakingly credits the result of the engagement to the sinking of three battleships by floating mines.

He answers the critics as to where the land attack should have been made by showing that the task of the small army was the reduction of the defenses located at the narrows and along the shore lines towards Sedd-el-Bahr and Kum Kale, but his strategy is at fault in critizing as impracticable an advance from Kum Kale. The Turks in April had but a small force on the Asiatic coast, and a division advancing from Mendere Chăi on Chanak, with its left supported by the fleet within the Straits, would have had but little difficulty in reducing Chanak before the Turks could have concentrated troops to oppose their march.

The second chapter is a highly painted word-picture showing, according to the author, the necessity of delay from March 18 to April 25 in attempting a landing, but he does not comment on the fact that when Ian Hamilton reached the Fleet on the 17th of March the allocation of the troops aboard the transports had been so poorly attended to as to make a landing impossible.

High tribute is paid to the bravery of the Anzacs and to the 29th Division of Regulars, who were to make the landings, and deservedly so, for the deeds of heroism performed by these men will do much to lessen, in the future, the sorrow caused by their ultimate failure to accomplish their mission. The landings at V, W, and X beaches are covered briefly, and follow Hamilton's and De Robeck's reports. More attention is paid to the work of the Anzacs, doubtless because this brave Corps is today, under the capable leadership of General Birdwood, winning additional honor on the Somme front. But the author says nothing about how the efforts of these brave men might have had a more successful outcome had the Navy covered their landing with due effectiveness; nor how the failure of the Anzacs to land at the selected point on the beach just north of Gaba Tepe, lost to them forever the opportunity to gain the Axmah Dere and pass thence into the Kilia Dere, from which valley it would have been possible to reach the coast near Maidos and secure control of the southern end of the Peninsula.

There is a strange silence, too, in regard to the 42nd Territorial Division, which is not included in the author's list of troops available for the landing. Maybe this omission was intentional, as Hamilton did not put these troops into the trenches until it was necessary to relieve the 29th Division after 17 days' day-and-night fighting.

The third chapter covers the period immediately following the landing and concludes with the general advance terminating May 8. The author answers for the benefit of the reader unacquainted with war, the question: "why did not the troops press on at once the day they landed?" He depicts in heart-rending terms the hardships of campaign, and of those conditions in particular which made these operations difficult. Similarly, instead of presenting a historical narrative of the succeeding days' events, he harrowingly describes what tortures and terrible experiences these troops encountered. Quite applicable were he writing of untrained soldiery, but hardly appropriate in describing the operations of a trained, reliable division like the 29th, or of a corps composed of men of the military efficiency of the Anzacs.

"* * * lying bleeding in the scrub with perhaps his face gone * * * in a place where none will find him, or be able to help him, a place where he will die and rot and shrivel, till nothing is left of him but a few rags and a few remnants and a little identification disc flapping on his bones in the wind."

Highly dramatic to say the least, and quite likely to make the untouched few at home quiver with unspeakable horror, but why so picture the scene when all Europe sorrows for the loss of some loved one. The author may be threading together words to make a horrible sound, but it is not history; not even the psychology of war, unless one is dealing with the untrained soldier being lead to slaughter under inefficient leadership, wherein the individualistic mind has not yet been merged into a cohesive mass. He should have prefaced his work: "Dramatic History," instead of declaring his purpose to tell "why" and "how" these things were.

In the fourth chapter the author skips to the events where reinforcements arrive, and presents an excellent picture of the Suvla Plain sector and the serrated hills in extension of Sari Bair. Using a contoured map to follow his description of the ground, the reader acquires a most comprehensive knowledge of the terrain over which the August fighting occurred.

Then follows in the fourth and fifth chapters a very entertaining description of the fight around Helles, and more particularly of the heroic and well sustained efforts of the Anzacs to take the key position of Lone Pine. But it is all written in haphazard narrative form, presenting a kaleidoscopic and incomprehensible tactical picture, without any reference to the strategy of the operations.

The author then turns to the action of the 10th and 11th Divisions at Suvla Bay. His description of the various engagements is interesting reading; but there is a commingling of fighting on Suvla Plains, Chunuk Bair, and still further to the south, that is hard to follow tactically. He refers to the failure of these divisions, which constituted the 9th Corps under General Stopford, to accomplish their mission, but does not tell us how poor leadership was responsible for it. The objections of the Division Commanders to advancing overbore the Corps Commander's wishes in the matter, the one fatal error being inertia. General Hamilton deemed it expedient to take command in person, and on August 15 relieved General Stopford.

With the failure of the 9th Corps to take the hills east of Kuchuk Anafarta and Biyuk Anafarta and thus connect with Sari Bair, all hopes of further success were at an end. General Hamilton asked for additional reinforcements and was refused. His recall was determined upon very soon thereafter.

Then rose the question: "* * * were our 100,000 men in Gallipoli containing a sufficiently large army of Turks to justify their continuance on the Peninsula," and the answer was "no." Bulgaria came into the fight in October and the cry of Serbia to her Allies to extend a helping hand was answered by the transfer of this force to Saloniki.

In writing of the evacuation, the author dismisses as unworthy the suggestion that the Turks let the Allies go; he thinks that the Turks did not know that the Peninsula was to be abandoned. But this does not seem possible. The evacuation of the Anzac position took eleven days, from December 8 to 19. At Helles the movement continued from the last days of December to January 9. It is inconceivable to believe that the withdrawal of the army from Gallipoli was not done with the tacit approval of the German and Turkish officers. In the latter part of October Sanders Pasha said he believed the Allies were thinking of evacuating their position, and after Lord Kitchener's trip to the Mediterranean, rumors of such a move were common. The Turks had an army of 350,000 south of the town of Gallipoli and 150,000 north of it, and with the Allies giving up their useless struggle for the Peninsula these troops would be released and made available elsewhere. It would be charging German leadership with a most serious blunder to assume that night reconnaissance by searchlight or otherwise, of the several coves off the Anzacs' position, could not have been provided for, had the Turks desired to adopt measures of surveillance which would make it extremely hazardous for the Allies to attempt a withdrawal, even under cover of darkness. It cannot be imagined that evidence of the withdrawal was unknown to the Turks. The Turks were glad to let them go.

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Military and Naval America. By Captain Harrison S. Kerrick, C. A. C. New York: Doubleday, Page & Co. 5¼" x 8¼". 389 pp. and index. Profusely illustrated; 2 maps and plates in cover pocket. 1916. Cloth. Price, $2.00.

The latter-day re-awakening of the military spirit in America has brought its response in the appearance of a number of manuals and text-books on military *technique* designed to help the citizen soldier. But there was no one source of authoritative information available for the thoughtful citizen concerned to know about the administrative organization, numbers, extent, and policies of our military and naval resources and establishments. A book to meet this need is now available in *Military and Naval America.* As expressed by the author, it is intended to be a *compendium of military and naval information.* After a careful scrutiny of its pages, one is justified in characterizing the book as an up-to-the-minute encyclopedia of administrative organization for the military and naval services of the United States. In addition, its dedication, foreword, the quotations from eminent Americans interspersed through the pages, as well as the scholarly introduction by President James of the University of Illinois, all stamp the volume as frank "preparedness" propaganda.

There are forty-six chapters in which are described, often in the exact language of official publications, the functions of the Army, Navy, Marine Corps, and Coast Guard; and the subdivision of duties through the various arms, corps, departments, and bureaus. In addition, there are chapters on the militia; military instruction in colleges; training camps; the National Rifle Association; the Red Cross; the Boy Scouts; garrison life; while of particular value are the chapters on a proper military policy, universal training, and *resources* vs. *power.*

To the Coast Artilleryman there is some significance in the fact that a chapter is devoted to the Coast Artillery Corps, with especial emphasis on gun defense; while another entire chapter is devoted to and entitled "The Submarine Defense of Harbors."

The volume is most profusely and excellently illustrated, and is replete with convenient statistical tables. In fact, these tables, scattered through the book, in connection with the two large charts furnished in a cover pocket, embody in accessible form the results of the most recent military and naval legislation and constitute the most valuable feature of the work from the standpoint of the regular officer.

Service Schools at Fort Leavenworth for the purpose of disseminating throughout the service, not only the sound principles of strategy and tactics but the mechanical technique of issuing orders in conformity with a routine that will make clear their meaning to others. The Coast Artillery officer desirous of perfecting his knowledge of troop leading, and this applies to the handling of coast defense troops as much as it does to mobile forces, will find no work more profitable than a careful study of these problems.

Part I deals with the offense, and involves the handling of units of every size from a patrol to a division. These problems, with the exception of the artillery situations and solutions, were originally prepared by Major Fiske and solved by the Line Class of 1913. The artillery situations and solutions have been prepared by Major Scott, and add much to the completeness of the work.

Part II deals with the defense, the situations and solutions having been prepared by the responsible officers for solution by the Class of 1915. The handling of the artillery is the work of Major Scott.

As the original problems with the approved solutions were issued to officers on the mailing list, an excellent idea of the Schools' progress may be obtained by carefully staking out and comparing the original with the present solution.

The best evidence of the progress made by the Military Art Department is its decision to issue a work of this nature for use as a text-book at the School. Much valuable time has been expended in conferences in times past in lengthy discussions as to the relation of the units of our army to those of the author of the foreign text, and even as to the accuracy of the translation itself.

It is believed that the school might well go still farther and publish selected problems for use as texts on other subjects than troop leading in lieu of the foreign texts now in use.

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Awake! U. S. A. By William Freeman. New York City: George H. Doran Company, 38 West 32nd St. 5½" x 8½". 453 pp. 70 il. Cloth. 1916. Price, $2.00.

William Freeman's *Awake! U. S. A.* gets to its point—accomplishes its purpose—arrives with a bang. But this is done in such fashion that one's admiration is spent on the writer's awkward gait rather than on his accomplishment. Exactly as one admires the elephant's lumbering ability to arrive at his destination in an exceedingly brief interval of time, without any real thought as to the pachyderm's miles per hour.

For *Awake! U. S. A.*, in spite of its style, belongs on the shelf right alongside Upton and Huidekoper. It is a perfect mine for the advocate of preparedness; rather, it is an unlimited supply of ammunition. Which means the author and the publisher, undoubtedly both, will be out of pocket on its account, as the time has not yet come when America will take to genuine preparedness with sufficient enthusiasm to make its literature profitable commercially.

Huidekoper's exploitation of the field General Upton opened, seemed so complete that one could hardly imagine room for another large volume devoted to the same cause. Yet with a synthetic genius, marvelous to behold, Freeman has vitalized statistics to the point where they become

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Journal of the United States Artillery

March-April 1917

COAST ARTILLERY SCHOOL PRESS
FORT MONROE, VIRGINIA.

JOURNAL UNITED STATES ARTILLERY

PRIZE ESSAY COMPETITION

Award of 1916

FIRST PRIZE: One hundred and fifty dollars to FIRST LIEUTENANT MEADE WILDRICK, C. A. C., U. S. ARMY.
Subject: *The Possibilities of Railroad Coast Artillery.*

SECOND PRIZE: One hundred dollars to CAPTAIN HOWARD L. LANDERS, C. A. C., U. S. ARMY.
Subject: *Initial Strategy on our North Atlantic Frontier.*

1ST HONORABLE MENTION: CAPTAIN PAUL D. BUNKER, C. A. C., U. S. ARMY.
Subject: *Lost Motion.*

2ND HONORABLE MENTION: FIRST LIEUTENANT OSCAR KRUPP, C. A. C., U. S. ARMY.
Subject: *Range Data.*

3RD HONORABLE MENTION: FIRST LIEUTENANT CRIS M. BURLINGAME, C. A. C., U. S. ARMY.
Subject: *Spotting for Coast Artillery.*

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Subject: *Preparedness of Fort Commands.*

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1917

The JOURNAL U. S. ARTILLERY announces the following for its annual competition.

PRIZES

One hundred and fifty dollars will be given for the best essay and one hundred dollars for the second best essay submitted on any coast defense subjects.

CONDITIONS OF THE COMPETITION

(a) Competition will be open to all readers of the JOURNAL.

(b) Award will be made by a committee of award, consisting of three persons, to be nominated by the Coast Artillery School Board. If no essay submitted seems to the committee worthy of a prize, none will be awarded. Honorable mention may be made of any essay submitted which seems to the committee worthy thereof, but to which a prize is not awarded.

(c) All essays entered in competition will become the property of the JOURNAL OF THE UNITED STATES ARTILLERY. These will be published, if approved by the Coast Artillery School Board.

(d) Copy must be typewritten, with lines double spaced, on one side of the paper only, and must be submitted in triplicate. If illustrations are included, one of the three copies thereof must be in the form of drawings, tracings, or photographs (not blue-prints nor brown-prints).

(e) Copy must contain nothing to indicate its authorship, must be signed with a *nom de plume*, and must be accompanied by a sealed envelope containing this *nom de plume* and the name of the writer. This envelope will remain in the hands of the Editor of the JOURNAL and, after award has been made by the Committee, will be opened in the presence of the Coast Artillery School Board.

(f) Copy must be received on, or before, December 31, 1917. It must be addressed JOURNAL U. S. ARTILLERY and the envelope must bear the notation, "Essay Competition."

JOURNAL
OF THE
UNITED STATES ARTILLERY

VOL. 47, No. 2 MARCH-APRIL, 1917 WHOLE No. 144

First Prize, Essay Competition of 1916

THE POSSIBILITIES OF RAILROAD COAST ARTILLERY

BY FIRST LIEUTENANT MEADE WILDRICK, C. A. C., U. S. ARMY

The question of adding coast defense guns and mortars mounted on railroad cars to our present system of seacoast fortifications, has been a topic of discussion among coast artillery officers for over a year. The purpose of this article is to discuss in a general way the possibilities of railroad seacoast batteries, and to suggest some rough ideas in hopes that they will be of interest, and thus form a basis upon which some definite system of value will ultimately be developed.

Under the present method of relying altogether on permanent seacoast fortifications, coast artillery officers are robbed of that greatest of all military prerogatives, namely, initiative. Their weapons are locked in one position, thus localizing the effect of their fire and unnecessarily sacrificing their fighting efficiency. The enemy, on the other hand, has all the advantages that come from having the initiative, being able to choose not only his time but also his point and formation for attack. Due to our present method of relying on permanent emplacements, the enemy would undoubtedly know the approximate position of every battery and could make his dispositions accordingly. This, then, is the position in which we find ourselves today.

The only way to rectify this situation is to give coast artillery officers some mobile weapons. This will then put them in a position to surprise the enemy by attacks from unexpected quarters and immediately put him on the defensive. In addition to the important service these guns and mortars can render in the immediate vicinity of our present seacoast defenses, they can also be used in conjunction with the mobile army to meet the enemy at his landing places and, when used in this way, they would undoubtedly inflict serious losses upon the hostile warships and transports and delay the enemy in his landing operations. This delay, if even for one or two days, would be of the most vital importance, as it would give us this additional time in which to concentrate our reserve forces in the threatened areas and enable us to offer more stubborn resistance to his landing parties. Most important of all, our larger guns and mortars would be able to shell the hostile warships covering the landing operations and compel them and the transports to keep well off shore. This would make the landing much more difficult for the enemy and at the same time would protect our mobile troops from the fire of the hostile warships. To emphasize this point, we will quote from the report of the General Staff upon the operations at the Dardanelles, which appeared in the May-June, 1916, issue of the JOURNAL U. S. ARTILLERY.

NECESSITY FOR HEAVY MOBILE GUNS

Although the Turks had ample warning of the impending attack, with an abundance of men to draw upon, and had guarded the most probable landing places with intrenchments and entanglements, the Allies succeeded in getting ashore. With the limited number of beaches suitable for landing, the Turks apparently had sufficient force to guard every one; but some were overlooked and the success of the Allies is due partly to that fact. The main reason for the success, though, is due to the fire of the covering ships, which would come in close enough to use all their guns and thus keep down the fire of the Turks. If the Turks had employed guns heavy enough to stand the ships off, the landing would not have taken place, for experience has shown that even the most powerful naval guns at long range are unable to put well-concealed shore-guns out of action. Even chance hits have little effect upon the sand or earthen parapets.

It may be accepted then as a fact that to prevent a hostile force from landing there must be, in addition to the usual infantry defense at all the possible landings, guns of sufficient power to keep the naval vessels at such a distance that their secondary batteries can not be used. Thus the landing of troops or supplies from ships at so great a distance from the shore can readily be prevented by the infantry and field guns.

In the case of a landing on our coast, the stretch to be covered is so long that it is impracticable to implace in prepared positions enough of these guns to cover all possible landing places. It will, therefore, be necessary to use mobile guns that can be quickly transported to the point threatened.

The quickest method of transportation appears to be a railroad paralleling the beach, from which spurs could be run to points near enough to the front to keep ships at about 8000 yards from the shore. The railroad, spur tracks, and gun locations should be prepared in time of peace.

We see, therefore, that the General Staff realizes the necessity of greater co-ordination between coast artillery armament and the mobile army, and it is hoped that in the near future this important development will materialize.

In case of war today a considerable number of coast artillery officers would not see service with coast artillery troops. They would be found as officers in all the other branches of the service, and their peace training would be for naught. This state of affairs is undeniably unsound, but the reason is obvious. The enemy in attacking this country would select but two or three sections of our coast-line for his landing operations, and the number of permanent seacoast defenses lying in the vicinity of these areas would probably be small. The coast artillery troops in the other defenses along both coasts, which were not needed to reinforce the threatened defenses, would thus be idle; and, being highly trained, they would be needed as siege artillery, field artillery, or infantry. This is a direct result of relying altogether on our present system of permanent armament. The only solution is to make a portion of this armament mobile, thus permitting us to rush railroad batteries to re-enforce a threatened coast defense or to meet the enemy at his points of disembarkation; and, backed by our mobile army, to actually serve as coast artillery and not harbor artillery. Our assistance to the mobile army in resisting a hostile landing would be of the most vital importance, and, as previously pointed out in the report of the General Staff, our peace training would actually prepare us for our ultimate duties in case of war.

The above discussion does not intend to convey the idea that our present harbor defenses would not be of great value in case of war, for they are and always will be of the greatest importance. It only tries to prove the necessity of enlarging the sphere of action of the guns and mortars emplaced in those forts, so that they could be used to their greatest advantage against an enemy. In case of war today our present seacoast defenses would play a most important rôle in the defense of our country. They would not only protect our important harbors, cities, and industrial centers from naval raids, but would provide our navy with safe bases from which to operate against hostile ships. The German coast defenses, especially those at Heligoland, give a striking example of how an inferior fleet can be protected against a superior force; and there are numerous other instances, not only in this war but throughout the pages of history, which clearly demonstrate the value of permanent seacoast defenses.

Hence we see that in protecting only our harbors our present system of seacoast defenses performs but half its mission. The long stretches of coast-line between our permanent defenses are absolutely undefended and offer to an enemy numerous and excellent landing places. This is the point, therefore, where our present system of coast defense breaks down, and it is with the idea of suggesting methods of correcting this weakness that this article is written. The chief objection advanced by those who do not believe in the practicability of railroad coast artillery is that it would be impossible to protect our whole coast by this system. This, of course, is true, but if it will only be remembered that this is not necessary and that there are only limited portions of our coast-line which would be of value to an enemy for strategic and tactical reasons, we will get the true relation of the value of railroad coast defense batteries.

In studying the military geography and strategic areas available for hostile operations along the Atlantic seaboard we find that only that portion lying between Portland, Maine, and Norfolk, Virginia, is of importance. A further study of the above area will likewise eliminate many portions of it for tactical reasons, on account of swamps, shallow water, etc. In this way we can select very accurately the points which an enemy would consider if he were operating against the Atlantic coast. Fortunately, there are numerous railroads and trolley lines paralleling this portion of our coast, and the proposed system of railroad artillery is thus especially adapted for the defense of this area.

The duties of coast artillery troops are, therefore, seen to be divided into two spheres of military operations:

1. The defense of our important harbors, cities, and industrial centers by means of our present system of permanent seacoast defenses, supplemented by mobile batteries for use in surprise attacks upon the enemy.
2. The defense of our intermediate coast-line of strategic value by means of mobile batteries acting in conjunction with our mobile army.

Today we are trained to perform only half our duty as coast artillerymen, and it seems only fair, both to our country and ourselves, that we demand proper weapons so that we can perform our whole duty as stated above. It is generally conceded that in case of war today some of our present seacoast armament, especially our mortars, would be dismounted and used as heavy mobile siege artillery. Why then should we wait for war to provide these weapons with a mobile mount? Why not perfect our plans now, in time of peace, so that upon the outbreak of hostilities we will be ready and trained to use this armament to its greatest advantage?

In considering the available methods for providing our seacoast defenses with mobile guns and mortars, we find there are two general means of transportation: one by motor tractor, hauling the guns and mortars over ordinary roads; and the other, railroad transportation. The difficulties encountered in moving major caliber guns over ordinary roads, due to their great weight, limits us at once to guns of intermediate caliber and 12-inch to 16-inch mortars or howitzers for use with motor tractors. Weapons of this type would prove of the greatest value for use in the immediate vicinity of our present seacoast defenses, but their use would be limited along most of our outlying coast-line, due to the lack of proper roads. The most efficient cannon of this type developed in the present war is the Skoda 30-centimeter (12-inch) howitzer. It was largely responsible for the initial successes of the German and Austrian troops and is in reality nothing but our 12-inch seacoast mortar mounted on a mobile carriage.

The field open to us, however, by mounting heavy seacoast guns and mortars on mobile railroad carriages is great and far-reaching. In the following pages we will try to look into the future and see what the possibilities of this system really are. We know definitely that both the French and the English have developed a gun of this type, whose caliber is as large as 13.5 inches, and it is reported on excellent authority that they are using guns of even larger caliber on a similar mount. Surely if the ordnance experts of those nations can solve the mechanical problems involved in firing and transporting such large weapons, our Ordnance Department can do likewise. Therefore, those who say that large guns mounted in this way are impracticable are mistaken and they are not keeping abreast of the times.

It is known that the Ordnance Department is now designing a railroad carriage mount for both a heavy seacoast gun and a large mortar. What these designs are the writer does not know, but for the purpose of illustration and discussion the following rough ideas are submitted. It is hoped that they will be criticised and improved upon by those having their own ideas on this subject, so that we may be supplied with modern weapons in the immediate future.

GENERAL DESCRIPTION OF THE DIFFERENT CARRIAGES

(See Diagrams 1, 2, and 3.)

The following designs of the railroad gun and mortar carriages have many points in common. We will, therefore, discuss these points first so as to save time and space. The hydraulic jack is used for raising or lowering the carriages between the traveling and firing positions. This is the present method used in mounting and dismounting large guns and mortars, and there seems no reason why it would not prove feasible. The hydraulic jack is simple, does not get out of order easily, takes up little space, and is capable of quickly lifting very heavy loads. It seems to fulfil all our requirements and is, therefore, suggested. A concrete base is used in all three designs, but supporting arms or wings might be substituted, especially in the design for the intermediate caliber gun mount. It is reported that some of the large guns and mortars used today in Europe are mounted on a base made by driving piles. We might use this method in case of necessity, but in general it would seem better to use concrete as it would give us a more firm and level base and, therefore, increase the accuracy of fire.

All three designs are leveled by means of four leveling bolts or wedges resting on leveling plates set in the concrete. This is the method now used in leveling our seacoast carriages and should be practicable. Each carriage is locked to the concrete base by means of securing or anchor bolts set in the concrete similar to those now used. The carriage is lowered from the traveling position to the firing position on the base, and raised from the base to the traveling position by means of the hydraulic jacks. Each truck is provided with a locking device by means of which the carriage can be locked in the traveling position, no weight being borne by the jacks after the carriage is thus locked. The following points should be noted: 1. The only time the jacks bear the weight of the carriage is during the short interval when actually lowering or raising same; 2. Upon discharge, all the recoil is taken up by the recoil cylinders, counter-recoil springs, and the concrete base. No part of the recoil whatever is taken up by either the trucks or the railroad track. There is an azimuth circle on each racer, which is oriented by sighting the gun or mortar on some predetermined datum point whose azimuth from the emplacement has been previously computed. In each design, as shown, the gun or mortar is mounted in a sleeve, the recoil being taken up by the recoil and counter-recoil cylinders.

Fig. 1 Carriage in Traveling Position.

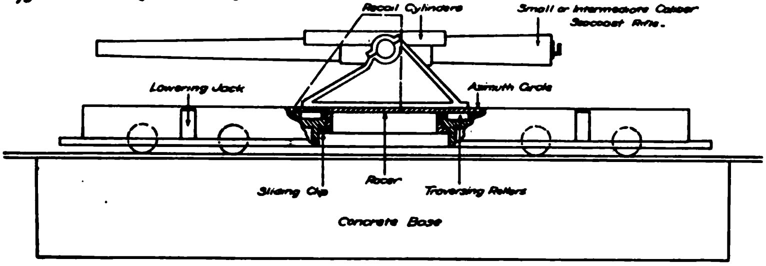


Fig. 2 Firing Position – Carriage lowered and locked to Base.

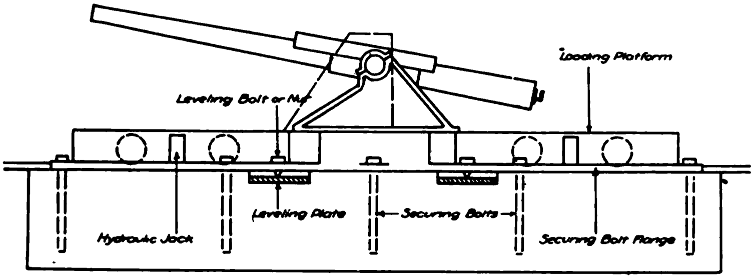


Fig. 3 - Top View

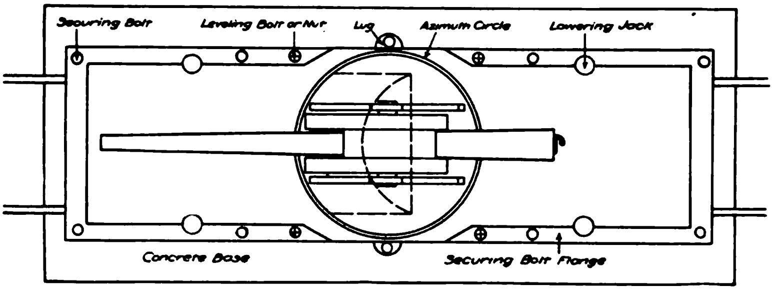


DIAGRAM 1.

1972

As drawn, each gun or mortar is mounted on a racer resting on a series of traversing rollers. The racer is held to the carriage by the sliding clips.

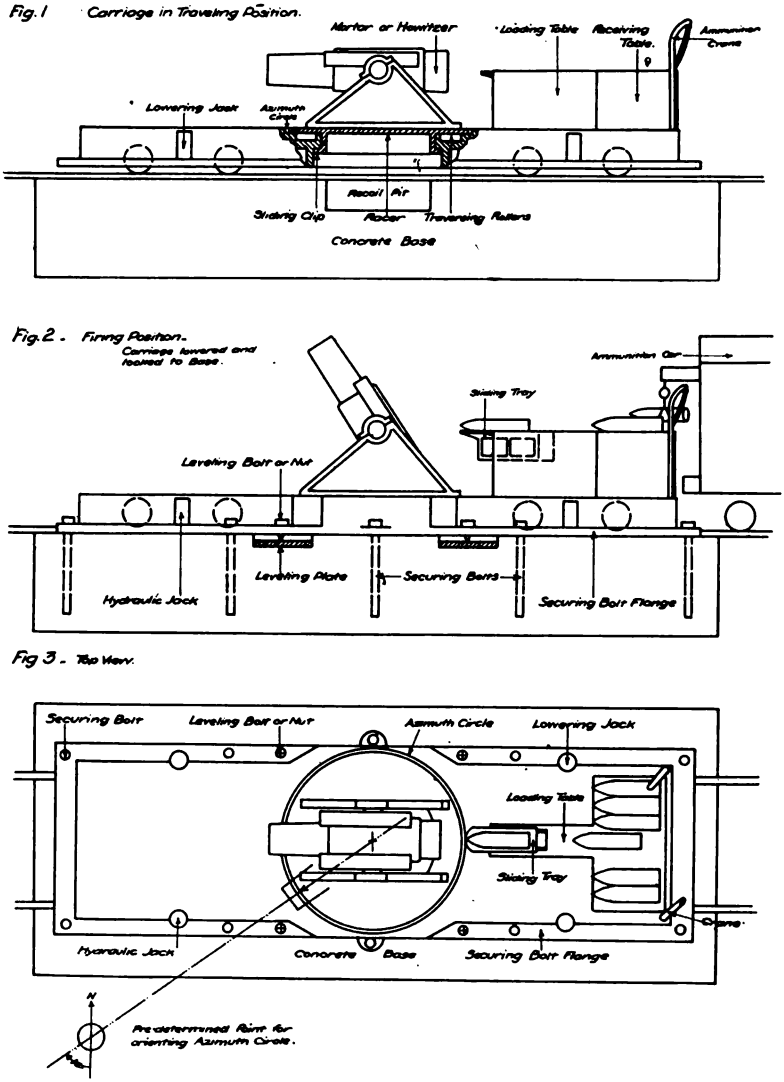


DIAGRAM 2. 1973

The general design of the concrete bases should be uniform and, if possible, so constructed that different types of weapons could be emplaced on the same base. This would be of the greatest advantage and would largely increase the fighting efficiency of the whole system. The positions for the bases should be selected in time of peace and, whenever possible, the bases should be constructed. For each base one or more base-lines should be selected for the fire-control system. This point, however, will be discussed more fully later. In case of emergency, where there is no railroad building material available, a supply of railroad tracks built in sections on steel ties should be kept on hand. The Japanese have successfully used this method in moving their heavy siege-guns on several occasions.

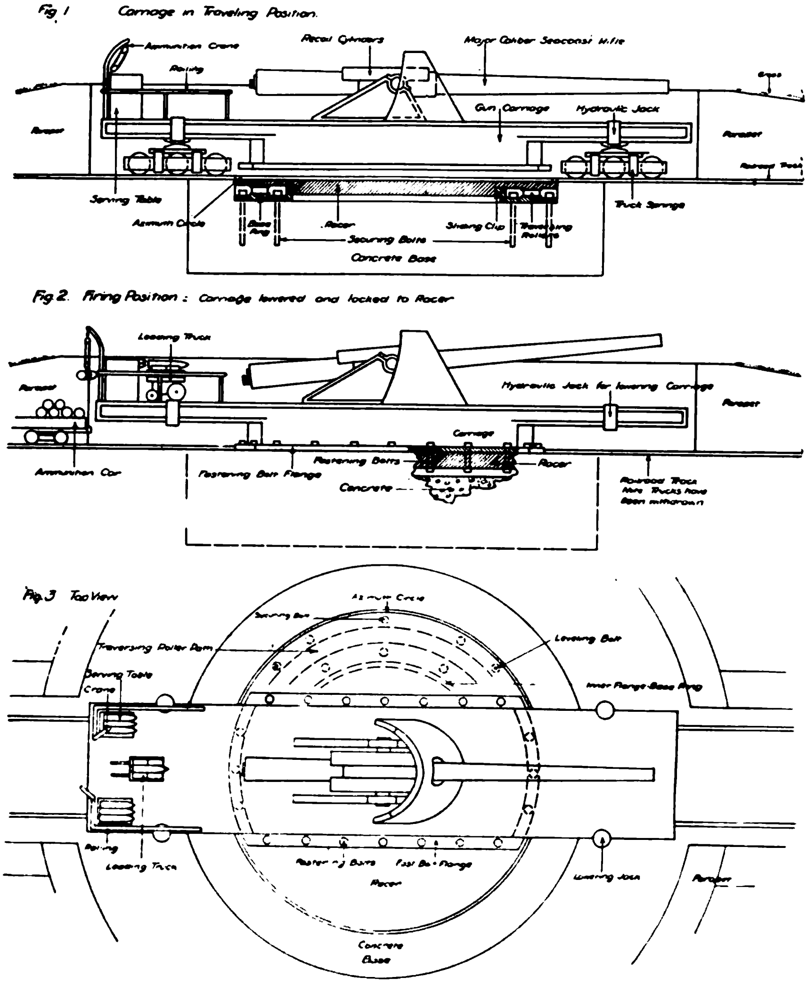


DIAGRAM 3.

1974

Parapets could be easily constructed for each emplacement. They could be rivetted with either a wall of concrete or with sand bags. Sand or dirt proved a better material than solid concrete at the Dardanelles in protecting the Turkish batteries from the fire of the Allied Fleet. Sand and dirt parapets besides costing practically nothing have the great advantage of being easy to conceal from hostile air-craft. In fact, all field fortifications are far superior in this respect to our present large and expensive permanent emplacements. In the accompanying designs a few branches and pieces of brush carefully laid over the carriages, tracks, cars, etc., would make the batteries invisible to hostile air-scouts.

Let us now briefly discuss the service of each carriage separately.

RAILROAD CARRIAGE MOUNT FOR INTERMEDIATE CALIBER SEACOAST GUN

(See Diagram 1.)

Roll the gun carriage on the base and lower it by means of the hydraulic jacks so that bolt holes in the securing bolt flange are directly over the securing bolts projecting through the concrete base. Take all the weight of the gun carriage off the trucks and level the carriage on the base by means of the leveling bolts or wedges. Secure the carriage to the base by tightening the securing-bolt nuts. Orient the azimuth circle, if desired, and the gun is ready for service.

If the enemy finds the range of the battery, or if it is desired to move to another emplacement for any reason, the following is all that it is necessary to do: Take off the securing-bolt nuts, raise the carriage to the traveling position by means of the hydraulic jacks and lock it. It is then ready for transportation.

It is believed that guns up to the 12-inch can be mounted successfully on a carriage of this type.

RAILROAD CARRIAGE MOUNT FOR SEACOAST MORTAR OR HOWITZER

(See Diagram 2.)

The design of this carriage is similiar to that previously described, and is nothing but a specially-constructed railroad flat-car of reinforced steel. If desired, two mortars could be mounted on the same car. To emplace the mortar carriage, roll it on the base and lower by means of the hydraulic jacks until all the weight of the carriage is off the trucks and it fits over the securing bolts. Level the carriage on the base by means of the leveling bolts or wedges, and secure to the base by means of the securing-bolt nuts. Orient the azimuth circle on some known datum point, and the mortar is ready to fire. Due to the weight of the projectile, a fixed loading table with a sliding tray is provided and placed at one end of the carriage. If necessary to move the carriage, take off the securing-bolt nuts, raise the carriage to the traveling position by means of the hydraulic jacks and then lock it.

RAILROAD CARRIAGE MOUNT FOR MAJOR CALIBER SEACOAST GUN

(See Diagram 3.)

The problems encountered in designing a carriage for a gun greater than twelve inches in caliber are more difficult. This is due to the increased size and weight of not only the gun and carriage, but also the racer. If desired to fire in a certain direction only, a base could be constructed along the lines of those previously discussed, the tracks and base being laid in the general direction of the target and the top carriage holding the gun so designed as to have a deflection of a few degrees on each side of the axis of the base. Such a mount, however, although it could be used in siege operations, would not fulfil the requirements of the coast artillery service, where the target is not confined to a limited area. For this reason, therefore, we must design a carriage which will have all-around fire. To obtain this result we have adopted the idea of a railroad locomotive turn-table. The design as drawn is nothing but a combination of the racer of our present disappearing carriage with a barbette mount. The racer revolves on a series of conical rollers resting on the base-ring and is held to the base-ring by the sliding clips. The base-ring is secured to the base by the securing bolts and is leveled by means of the leveling bolts or wedges.

To emplace the gun carriage, roll the carriage on the racer and lower it by means of the hydraulic jacks so that the fastening bolt holes fit over the fastening bolts. Take all the weight of the gun and carriage off the trucks and secure the carriage to the racer with the fastening bolts. Disengage the trucks and withdraw them so that they will be out of the way.

Orient the azimuth circle and the gun is ready for service. On account of the great weight of the projectile and powder charge, some loading device is necessary. As drawn, the carriage is provided with two serving tables with ammunition cranes and the ordinary loading truck.

To prepare the gun and carriage for transportation, roll up the trucks and engage them to the carriage. Take off the securing-bolt nuts, raise the carriage on the trucks by the hydraulic jacks, and lock it in the traveling position. The gun and carriage are then ready for immediate transportation. It might be advisable to make the base-ring traversing roller system and racer in sections so that they could be carried along with the battery.

AMMUNITION SERVICE

(See Diagram 4.)

The need of a prompt ammunition service is a most vital question. It is easily solved, however, by the use of specially designed ammunition cars. In fact, cars of this type used in conjunction with our present permanent emplacements would be superior to the system of supply now employed at our batteries. In case of hostilities it would be an easy matter to ship ammunition in these cars from any section of the country to the threatened coast defenses. The employment of these cars in serving the mobile guns and mortars previously described would be indispensable.

In Diagram 4 is shown a design for an ammunition car which should prove practical. The car is built of steel, the sides providing protection against rifle and shrapnel bullets. The roof is reinforced to give protection against aerial bombs. A machine gun is mounted on the roof of the car for use against raiding parties or hostile air-craft. The car is divided into three sections: the two end sections are for the storage of powder cases; the center section for storage of projectiles. This arrangement is used so that the weight would be evenly divided on both trucks. The car is designed to carry complete charges (i.e., powder and projectiles), so there will be no chance of a shortage of either powder or projectiles.

The powder charges and projectiles are carried on a system of overhead trolleys so arranged that they can be connected through a series of cars. The projectiles in a car are loaded on a serving table in the center of the car by means of a second-

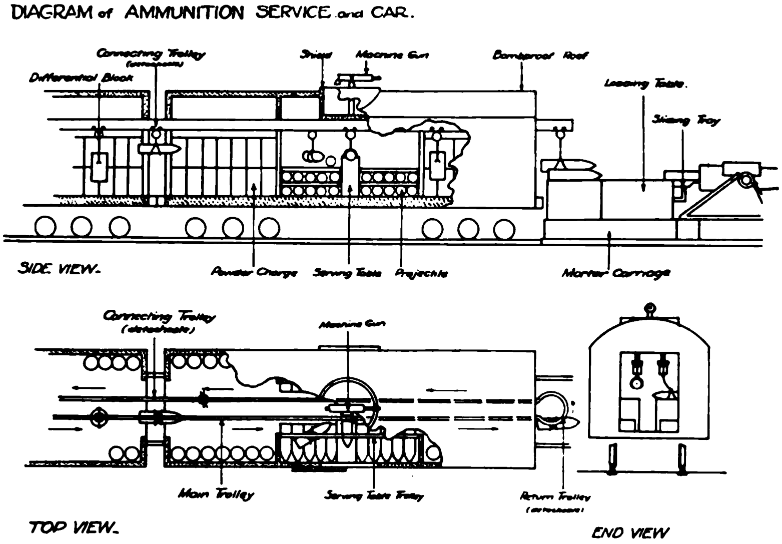


DIAGRAM 4

1975

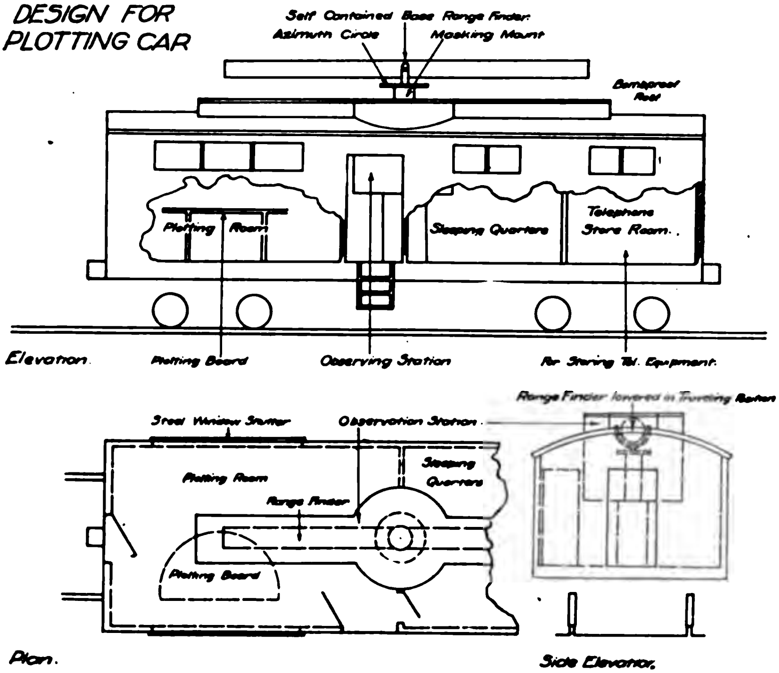


DIAGRAM 5.

1976

ary or serving table trolley. They are here picked up by the main trolley system when being carried forward to the guns. Upon reaching the serving table at the guns there are three general methods of loading that could be used: a fixed loading table with sliding tray, as shown in Diagram 2, for mortars; a loading truck, as shown in Diagram 3, for large guns; or an extension of the overhead trolley to the breech of the gun or mortar.

PLOTTING CAR

(See Diagram 5.)

For accurate shooting there must be an efficient fire-control system. This necessitates the use of a plotting car, where the necessary fire-control equipment can be stored and kept ready for service. In Diagram 5 is shown a suggestion for such a car. It is divided into three compartments: the plotting room proper with the necessary telephone connections; the sleeping quarters for the plotting-room detail; and a store room where telescopes, telephones, and field buzzer equipment, etc., can be kept for rigging up a fire-control system in the field. For emergency conditions, the car is equipped with a self-contained base range-finder installed on a masking mount. The car is constructed of steel to give protection against rifle bullets, shrapnel, and aerial bombs.

SEARCHLIGHT CAR

(See Diagram 6.)

Another necessary unit of this mobile armament is a searchlight car. A suggestion for such a car is shown in Diagram 6. The searchlight is mounted on a base which can be raised to the level of the roof of the car by means of a system of gears. The car is divided into three parts: the shelter for the searchlight when not in use; the power-plant; and the sleeping quarters for the manning detail. The car is provided with either a machine or an anti-aircraft gun for protection against hostile air-craft. Cars of this type would be most valuable for use today in all our coast defenses. The car is also provided with auxiliary motor power from its own power-plant, thus giving it limited mobility. If attacked at night by hostile air-craft, or if its position has been found by the hostile guns, all that is necessary is to put out the light and move under its own power to a new position. The car is built of steel to provide protection against rifle bullets, shrapnel, and aerial bombs. A parapet of dirt could easily be thrown up around the car to provide additional protection and make it invisible to hostile air-craft.

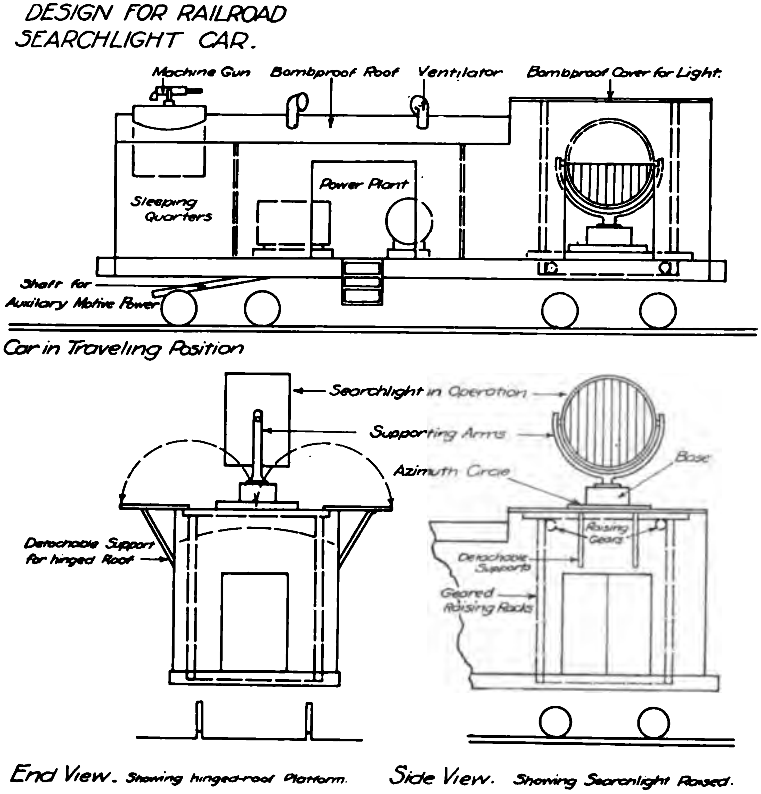


DIAGRAM 6. 1977

MACHINE SHOP CAR

(See Diagram 7.)

In Diagram 7 is shown a suggestion for a Machine Shop Car. When serving the batteries in the field under service conditions and away from the home Coast Defenses, many repairs will have to be made without delay. The above requirements could be met by using a car of this type, which is equipped with standard lathes, milling machine, forge, etc. The car is furnished with its own power-plant which could be used if desired for motive power, as described for the Searchlight Car. It would not be necessary to have a car of this type for each battery; one assigned to each Railroad Coast Artillery Unit, *i.e.*, a fire command or battalion, would probably be sufficient.

The Value of Railroad Coast Artillery in the Vicinity of Our Present Coast Defenses

(See Diagrams 8, 9, and 10.)

This system of railroad artillery offers today one of the greatest opportunities ever presented to the coast artillery for obtaining modern weapons. The majority of our seacoast guns and mortars are from twenty to twenty-five years old, and at present there seems little hope of securing modern armament. Our armament has been patched up and added to from time to time until today we have eight distinct types of guns, ranging in caliber from 3 inches to 16 inches. In case of war the service of the ammunition supply for these guns would be a most difficult problem, necessitating, as it does, special tools for making projectiles and powder grains of so many different sizes. This state of affairs is obviously unsound and is largely due to the fact that the last twenty years has been a period of experimentation. Now, however, we have passed through that stage and, after studying the lesson of the present war, we know what we need. There should be more co-operation between the Ordnance Department and the Coast Artillery Corps. It should be the function of the Coast Artillery Corps to select and draw up the specifications for their weapons, just as the Cavalry select and design their sabers and saddles. It should then be the function of the Ordnance Department to build these weapons.

The Navy has discarded guns of varying calibers from their ships, and now rely on but two sizes, a heavy gun for primary armament and an intermediate caliber gun for secondary armament. We should do likewise, thus simplifying and standardizing our ammunition supply and preventing loss of fighting efficiency in shifting troops from one battery to another.

In adding modern guns and mortars mounted on mobile railroad carriages to our present seacoast defenses, there would not be any loss in the accuracy of fire. (See Diagram 8.) These weapons would be mounted on carriages similar in a general way to our present permanent carriages; they would be secured and fired from concrete bases as at present; they

Machine Shop Car — (For repairs in the field.)

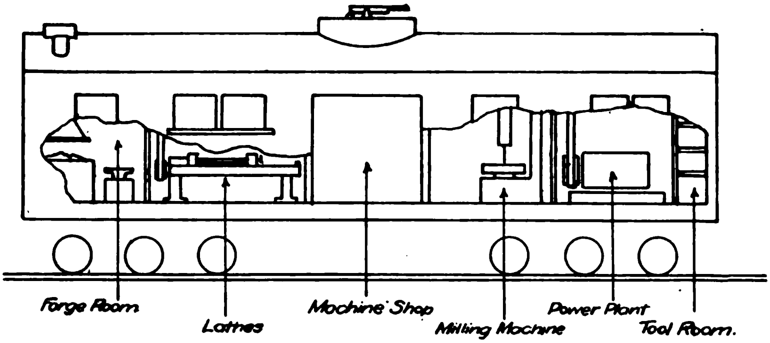
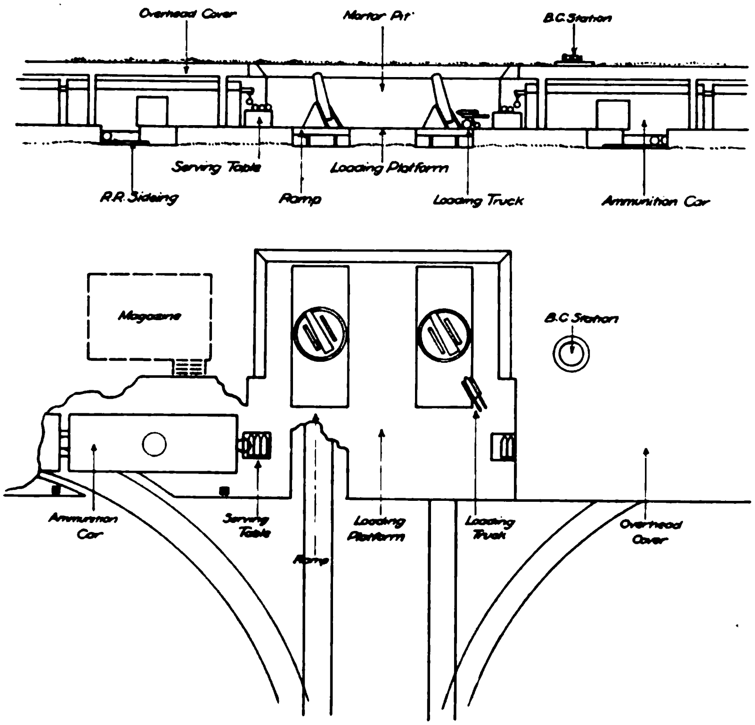


DIAGRAM 7.

1978



SEMI-PERMANENT RAILROAD EMPLACEMENT

DIAGRAM 8.

1979

could be fired with the same fire-control system; the only difference between the two mounts being that one is so designed that it can be quickly and easily transported by rail. Another great advantage of this mobile mount is that the guns and mortars can be taken to gun factories and have new weapons quickly installed, just as a battleship goes to a navy yard and has new guns placed in its turrets. Under our present system of permanent mounts this is impossible, due to the great cost involved, and is one reason why we never get new guns.

With this system of mobile armament we would be in a position to rush batteries to reinforce a threatened coast defense, just as the Germans rushed heavy guns and howitzers to the Turks at the Dardanelles. For example, the seacoast armament guarding the Panama Canal could be used at either end as desired, and also the guns and mortars on the Pacific Coast of the United States could re-enforce those on the Atlantic Coast. Today, however, this would be impossible, relying as we do on our permanent emplacements. When used in our coast defenses two or more emplacements could be constructed for each railroad battery, and they could be used for attacking the hostile ships from unexpected points. Parapets could be quickly constructed of sand and dirt for not only the guns and mortars, but also the plotting and ammunition cars.

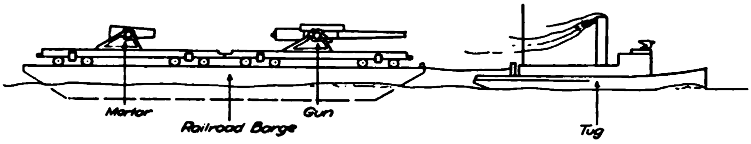
The question of transporting this proposed railroad armament to and from a coast defense can be easily solved by the use of railroad barges, as shown in Diagram 9.

At all our coast defenses we have docks already built, and the only change necessary would be the laying of a mile or so of track to the emplacements. The headquarters for the batteries or fire commands, where two or more batteries are combined, would be at our present coast defenses. When not needed for duty elsewhere, these batteries would be emplaced and served as our permanent batteries are at present. They should always be kept ready, however, for field duty, and to test their mobile powers they should be required once a week at artillery inspection to move some distance along the track or take up a position in another emplacement.

Target practice should prove a very interesting problem. The requirements should, as far as possible, simulate war conditions. It might be desirable to have two practices, one at the home coast defense under our present conditions, and one in the field along the adjacent coast-line under conditions similar to those described in the following pages.

The coast artillery barge offers great possibilities as shown in Fig. 1, Diagram 10. A barge of this type should be assigned to each Coast Defense. Its value for transporting armament has already been discussed. Positions can be prepared on the decks for mounting the previously described guns and mortars for use in emergency and when the conditions are favorable. When used in this way it would form a valuable unit of our coast-defense system in protecting rivers, shallow bays, etc. The barge is provided with landing aprons to facilitate loading and unloading of armament with varying heights of tide. A spotting bridge could be placed on top of the apron cranes for controlling the fire of the guns and mortars. The barge itself or the cranes could be equipped with pile-driving apparatus,

Fig. 1. Transportation on Water.



Note: — For Defense of Land and Water Areas inaccessible to Railroads and Ordinary Roads.

Fig. 2. Battery Landing

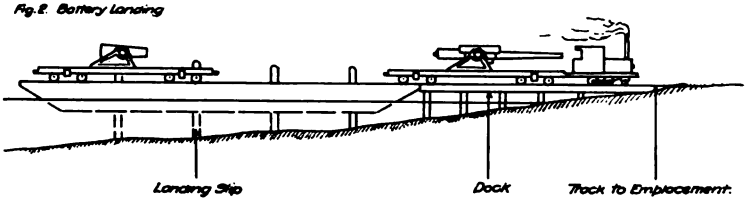


Fig. 3. Diagram of (5) Emplacements, in One Coast Defense.

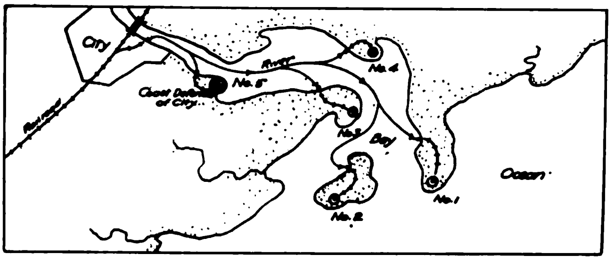


DIAGRAM 9. 1980

thus permitting it to build its own landing docks. In addition to the above the barge readily adapts itself to mine planting by placing davits along the sides. In case no mine planter is available, the barge could render valuable assistance. When used in conjunction with the mobile submarine mine system described in the following paragraph, important water areas, not accessible under our present system, could be quickly and easily mined. Small guns could be mounted on these barges for use against hostile destroyers when transporting armament from one point to another and in protecting the mine-fields mentioned above.[4]

Fig. 1. Possible Developement of R. R. Coast Artillery Barge.

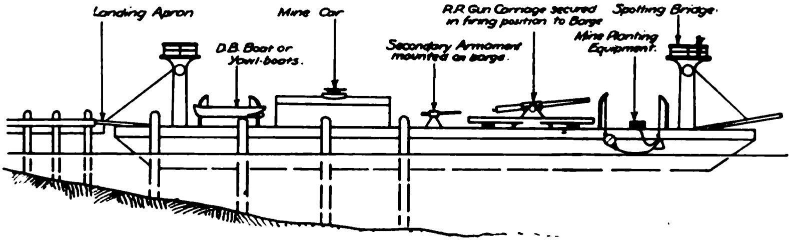
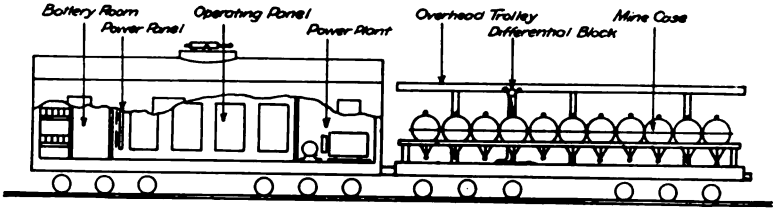
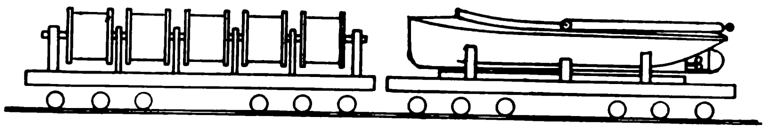

Landing Apron
Mine Car
R.R. Gun Carriage secured in firing position to Barge
Spotting Bridge.
D.B. Boat or Yawl-boats.
Secondary Armament mounted on barge.
Mine Planting Equipment.

Fig. 2 Proposed R.R. Coast Artillery Submarine Mine System.



Mineing Casemate Car. *Mine Case Car.*



Mine Cable Car *D.B. Boat or Yawl-boat Car*

DIAGRAM 10. 1961

In Fig. 2, Diagram 10, is shown a proposed mobile submarine mine system designed to supplement our present equipment. The arguments for such a system are the same as for mobile guns and mortars. It would provide another element with which to surprise and delay the enemy, thus giving coast artillery officers another opportunity of exercising initiative. There are many points along our coast where such a system could be used to the greatest advantage. For example, Long Island Sound between Forts Wright and Totten, the mouths of Delaware and Chesapeake Bays, the Potomac River, etc. The difficulties encountered in installing this system would not be great. This offers a new and interesting field for future development and experiments should be undertaken to determine its practicability.

THE VALUE OF RAILROAD COAST ARTILLERY ALONG OUR COAST-LINE

(See Diagrams 11, 12, and 13.)

The value of railroad coast artillery in protecting important undefended points along our coast-line between our present coast defenses has been discussed earlier in this article. Due to the exposed positions in which these batteries would be placed, it would be necessary to have mobile troops in the immediate vicinity to protect them from raiding parties. Positions for these batteries should be selected in time of peace and, if possible, the bases constructed with the necessary railroad spurs. If the batteries were supplied with sections of tracks built on steel ties, the connecting spurs could be laid only when needed. If there are no railroad trunk-lines in the vicinity of the proposed emplacements, the batteries could be easily transported to the locality to be defended by water, using railroad barges as shown in Diagram 7. A rough landing dock could be quickly built and a spur track laid from the dock to the emplacements.

The batteries, combined as necessary into fire and battle commands, would have our present seacoast defenses for their home stations. The coast-line would be divided into sections and these batteries would be assigned to the defense of that section of the coast-line adjacent to their home defenses. When not in the field the troops assigned to these batteries would live in barracks and serve their batteries in our permanent Coast Defenses as at present. For a month or so during the open season they should be required to live in the field under war conditions and have a service practice during this period. When serving in this way they could either live in sleeping or barracks cars or under canvas, as desired.

The fire-control system for the batteries when emplaced in the field could be similar to that now used with our permanent batteries. The stations could be simple concrete structures as shown in Diagram 11. If desired, they could be covered with earth when not in use so as to keep their exact location a secret. When prepared for service all that would be required would be to dig them out, lay the field telephone or buzzer lines, and set up the observing instrument, using the fire-

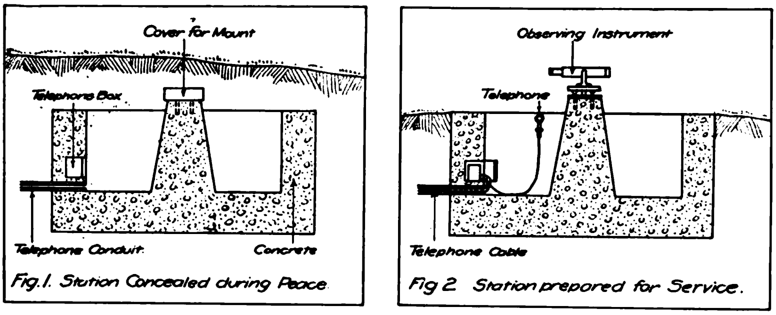


Fig. I. Station Concealed during Peace

Fig 2. Station prepared for Service.

Design for Observation Station.

DIAGRAM 11. 1982

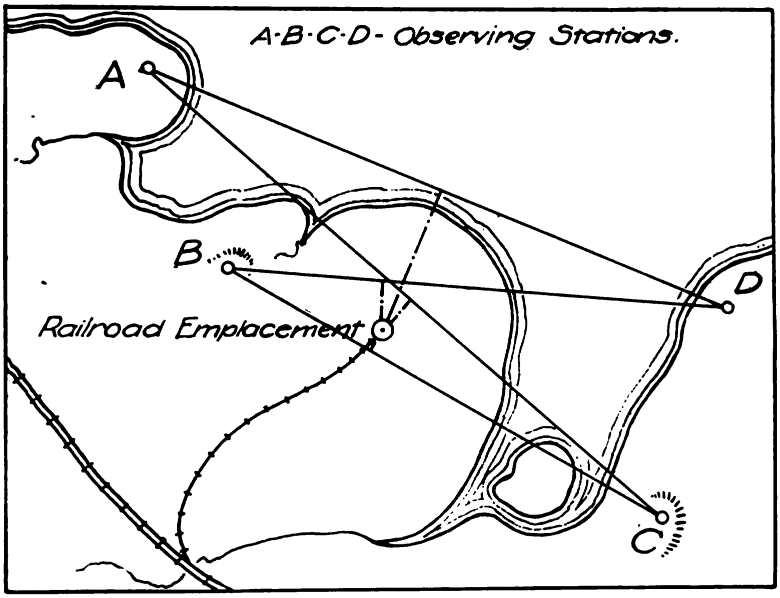


Diagram of Auxiliary Base-Lines.

DIAGRAM 12. 1983

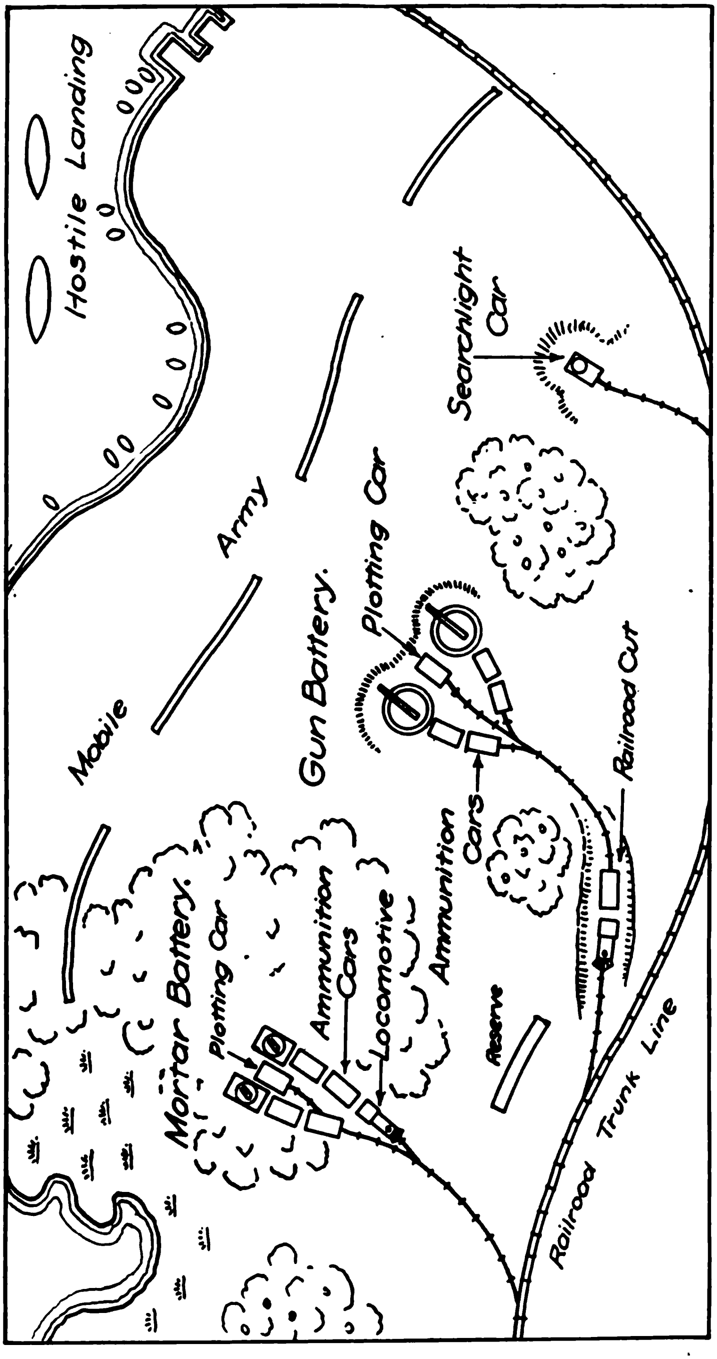


DIAGRAM 13. SHOWING USE OF MOBILE ARMAMENT IN COAST DEFENSE

1984

control equipment stored in the plotting car shown in Diagram 5. The stations could be easily concealed from hostile aircraft by using brush.

For each emplacement several base-lines with the necessary observing stations should be laid out as shown in Diagram 12. The lengths, azimuths, heights of sites, etc., should be computed in advance and kept as a permanent record for each emplacement. The battery commander when connecting up his fire-control system could then consult these records and quickly set up his plotting board, orient his instruments, and make other necessary adjustments. For emergency fire-control, he could use the self-contained base range-finder installed on the plotting car.

Upon the outbreak of war these batteries, combined into trains with the necessary auxiliary cars and equipment, would be sent to their assigned emplacements. The trains, as previously described, are provided with machine and anti-aircraft guns, and are made as self-supporting as possible.

They could be used as shown in Diagram 13 to assist the mobile army in resisting hostile landing operations. Every advantage should be taken of railroad cuts, woods, hills, etc., to protect and conceal various units from the hostile fire. If during later stages of the war it becomes necessary to resort to trench warfare, these same guns and mortars would prove invaluable in strengthening the lines held by our army.

To supplement the fire-control system previously described, all mobile fire commands or separate batteries should be supplied with the following additional equipment: aeroplanes, captive balloons, and field wireless; the aeroplanes to be used for spotting the fire of the batteries and for protecting the captive balloons, when used, against the attacks of hostile air-craft; the captive balloons to be used for observing the fire of the batteries, having direct telephone connections with the batteries; the wireless to be used for security and information, and to provide communication with the spotting aeroplanes in controlling the fire of the batteries. The wireless could be easily rigged on the plotting car shown in Diagram 5 by providing telescopic masts at either end of the car.

If equipped with such a system we could easily fire battery or fire command salvos and quickly get on the target at long ranges. This method of fire-control has become necessary due to the great ranges of modern weapons, and is the system which we will undoubtedly have to develop in the near future.

CONCLUSIONS

Let us now consider the comparative costs of this railroad system with our present permanent system. The following table will give the approximate cost of our present equipment:

Type	Gun	Carriage	Battery Emplacement
6-inch Disappearing Gun	$ 9,500	$15,000	$ 30,000
14-inch Disappearing Gun	60,000	72,000	150,000
16-inch Mortar	10,000	15,000	150,000

Assuming then that we standardize our armament, as above, and select a 6-inch gun for our secondary armament, and a 14-inch gun and 16-inch mortar for our primary armament, we come to the following conclusions: the cost of the gun or mortar itself would be the same under both systems; the cost of a railroad carriage for a 6-inch and 14-inch gun, respectively, would be a great deal less than the cost of the present disappearing carriage; and there would be almost a total saving on the great cost of the present permanent emplacement, since the field emplacement for the railroad battery costs practically nothing. It is therefore seen that practically two railroad batteries can be supplied and emplaced for the cost of one permanent battery under the present system.

In conclusion let us briefly review the preceding discussion and consider the advantages that would be obtained by supplementing our present coast defense armament with mobile railroad batteries.

1. Under the present system of relying altogether on permanent armament, the hostile fleet has all the advantages of having the initiative, and coast artillery troops are forced to content themselves with merely the rôle of a passive defense. If given some mobile weapons, however, they could inflict losses upon the enemy by surprise attacks and delay him in his operations both on sea and land.

2. With a complement of railroad seacoast batteries it would be easy to quickly reinforce a threatened coast defense, just as the Germans reinforced and saved the Turks at the Dardanelles. This, however, would be impossible under our present system, and would result, in time of war, in many idle coast artillerymen.

3. Under our present system coast artillery troops perform

but half their mission—that of harbor defense. The power of their weapons is localized, and their fighting efficiency unnecessarily wasted by permanently locking them in one place. By using mobile batteries, on the other hand, their sphere of operations can be extended along our entire coast-line, as shown in Diagram 13, and they can perform their whole duty as coast artillerymen. Moreover, in case of necessity, these same mobile seacoast batteries can be used in trench warfare as similar weapons are being used today on the battlefields of Europe.

4. For strategical and tactical reasons it would be necessary to defend only limited sections of our coast-line. There are docks at all our coast defenses and, by laying short railroad spurs connecting the docks with the emplacements in the coast defenses, railroad batteries could be easily transported by water, as shown in Diagram 9, to any point along the coast. Using this method they would not be dependent on existing railroad lines, and could use the many canals and inland water routes along the Atlantic Coast.

5. Our present permanent emplacements are very expensive and impossible to conceal from hostile air-craft. By using railroad batteries, however, we obtain greater defensive power at less cost, and, in addition, we can easily make the batteries invisible to hostile air-scouts.

6. If it becomes necessary to surrender under our present system, our whole equipment becomes a total loss. With mobile weapons, on the other hand, we will have an elastic system and can fight a delaying action, slowly retiring when necessary from one position to another as shown in Diagram 9.

7. At present if an enemy locates the position of one of our permanent batteries, it would have to stand as best it could the hostile shower of shot and shell. If, however, this battery was provided with a mobile mount with two or more emplacements, it could quickly take up a new position and baffle the fire of the hostile ships or of hostile siege artillery.

8. The fire of the railroad seacoast batteries can be controlled by the same fire-control system as that now used with our permanent armament. There should be no loss in accuracy of fire, as the railroad carriages, shown in Diagrams 1, 2, and 3, are similar and therefore as securely emplaced as our present permanent carriages.

9. Today the accuracy life of our seacoast guns and mortars is a critical question, resulting in the use of reduced powder charges. Moreover, many of our present guns and

mortars are out of date, and it is impossible to install modern weapons, due to the great cost involved in transporting and mounting new armament and in remodeling old emplacements. This question is quickly solved, however, by the use of mobile railroad batteries, as these batteries can easily be sent to an arsenal for new guns or repairs, just as a battleship goes to a navy yard. This should insure our being constantly equipped with modern weapons.

10. Last and most important is the fact that today we have an opportunity to start over and build on a solid foundation. Using our permanent seacoast defenses as the backbone of the system of the future, we can add modern and powerful mobile weapons to our present armament. This will give us a chance to standardize our armament, thus simplifying our ammunition service and greatly increasing our fighting efficiency. We should make the most of this opportunity now, as it will probably not come again until we ourselves are involved in a great war. Then, however, it will be too late.

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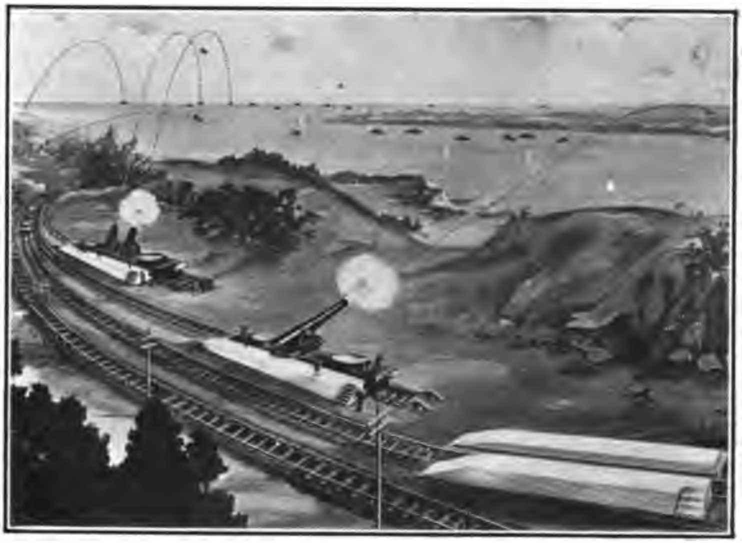

FIG. 1. 1985

REPELLING AN ATTACK ON AN UNFORTIFIED SECTION OF OUR COAST

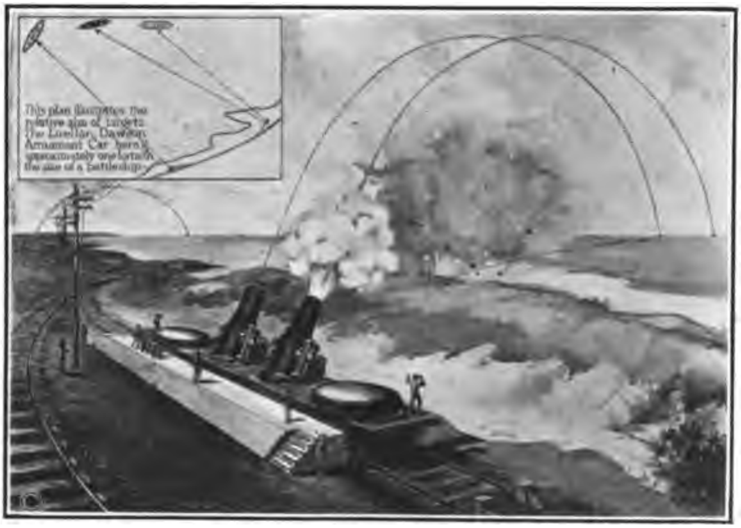
This plan illustrates the relative size of targets. The Loeffler-Dawson Armament Car here is approximately one-tenth the size of a battleship.

FIG. 2. 1986

MORTARS IN ACTION AGAINST CAPITAL SHIPS

our seacoast defenses can and should properly be considered of two classes, viz.:

1. Harbor defense.
2. Coast defense.

The first, that of harbor defense, has to do with the care and use of the fixed and movable elements of the seaward and landward defense of our harbors, roadsteads, and anchorages. The second involves the care and use of the fixed and movable elements of the seaward and landward defense of our coastline not covered by the defenses of the first class.

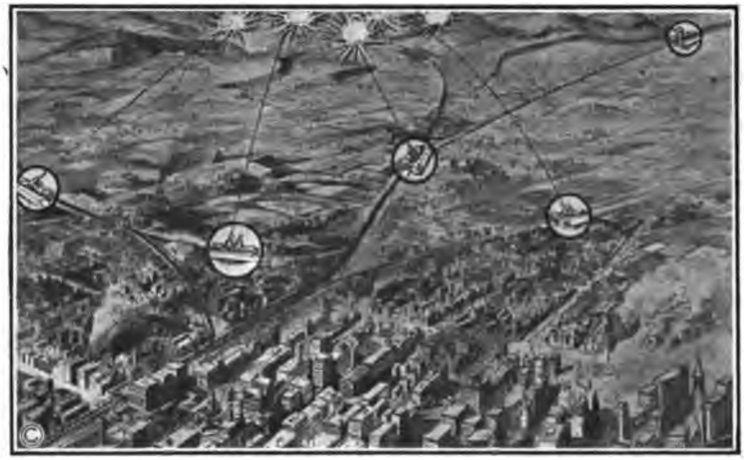

Fig. 3. 1987

Mobile Armament Assisting in the Defense of an Inland City

The present condition of our roads, bridges, and general topography of the country makes it difficult to rapidly move very heavy ordnance thereon; but we are fortunate in having a network of railroads, many of them paralleling our coastline, which, if utilized, will go far in solving our problem of coast defense.

The strategic value of mobile heavy artillery as an adjunct to our fixed defenses has long been recognized, and the results obtained in the present war have finally crystalized many ideas along that line.

For some time past, officers of the Ordnance Department, as well as of the Coast Artillery Corps, have considered and proposed some means of rapidly covering unfortified sections of our seacoast by heavy mobile armament and some of these schemes of defense have been worked out in considerable detail.

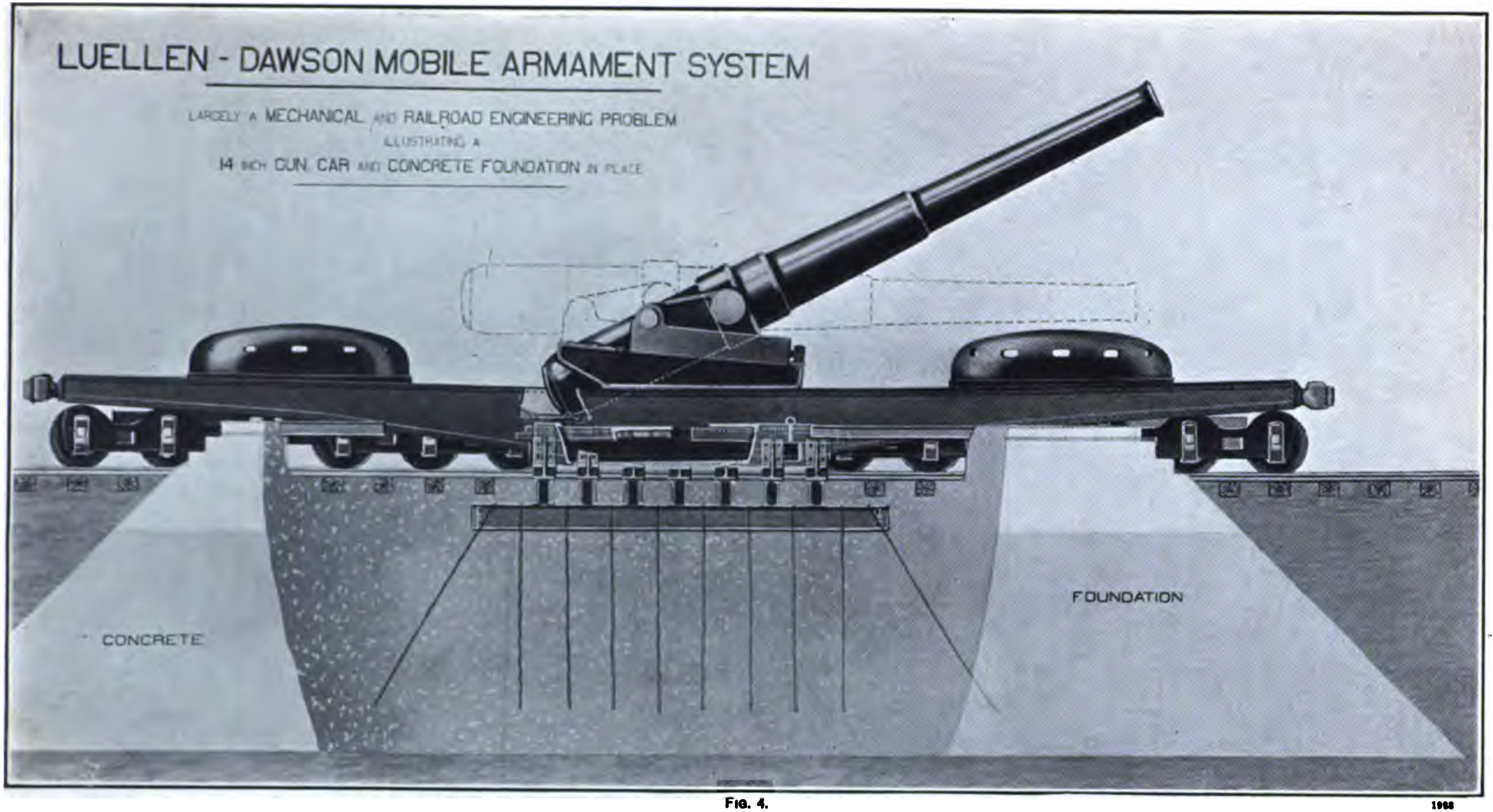
LUELLEN - DAWSON MOBILE ARMAMENT SYSTEM
LARGELY A MECHANICAL AND RAILROAD ENGINEERING PROBLEM
ILLUSTRATING A
14 INCH GUN CAR AND CONCRETE FOUNDATION IN PLACE
CONCRETE
FOUNDATION

Fig. 4.

In this connection a system of mobile armament suggested by Mr. L. W. Luellen, known as the "Luellen-Dawson Mobile Armament System," will no doubt prove of considerable interest, at this time, to the Coast Artillery Service. This system contemplates the mounting of heavy guns and mortars on specially constructed railroad cars which it is proposed be arranged mechanically so that the cars carrying the armament may be rapidly transported to any point along our railway lines and quickly locked to concrete foundations or bases. A type of base is shown in Fig. 4.

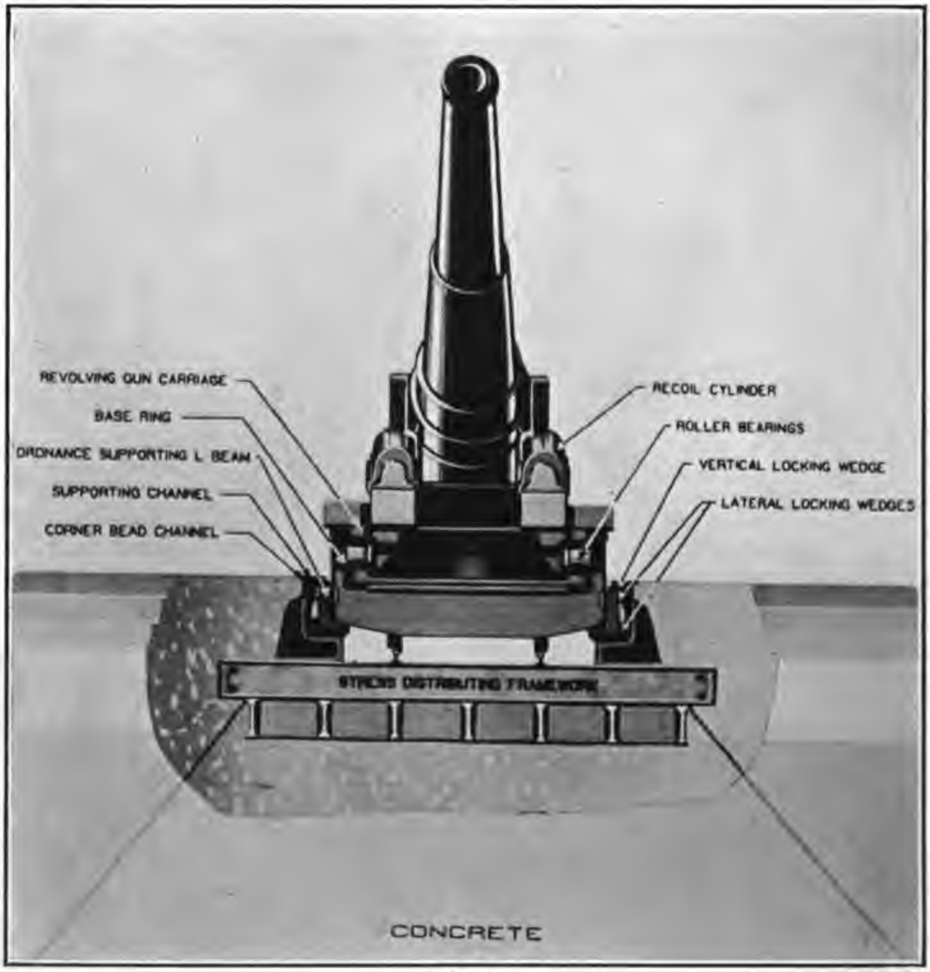

FIG. 5.

It is further contemplated that these concrete bases will be prepared in advance at predetermined locations, arranged under or alongside of the railroad track in such a manner as to permit of the guns or mortars, on their traveling carriages, being quickly placed in the firing position on these fixed bases or promptly withdrawn if for any reason it was found desirable to do so.

One type of base with the mechanical arrangements for quickly locking the gun with its carriage in place, is shown in detail in Figs. 4 and 5. These bases are to be constructed of reinforced concrete of sufficient dimensions to properly take care of the stresses developed in firing guns of as great a caliber as 16 inches.

Referring to Fig. 5 it will be noticed that the base contains two channels, one on either side of and above the track. It will also be noticed that these channels are inclined upward from the entrance end of the base toward the other end. The supporting "L" beams, or shoes on the traveling carriage, enter the channels on either side of the base and slide along the same into place gradually raising the gun and carriage a sufficient amount to take the weight off the car trucks. Hence, when fired, the stresses are transferred from the gun carriage to the concrete base. The carriage is locked on the base by a vertical locking wedge indicated in the figure.

It is proposed that the cars for this armament will be so designed as to utilize the present coast and inland railways as a partial means of building up a coast defense system that will permit of sufficient flexibility to concentrate a number of high-power guns at strategical points along our seacoast for use as an adjunct to our harbor defense or for repelling an attack on an unfortified section of the shore.

A large part of our coast-line is paralleled by coastal railroads, especially that of the eastern seacoast. The present railway facilities along the coasts of Massachusetts, Rhode Island, New York, and New Jersey are typical and so located that ample gun foundations could be located on spurs, or side tracks, so that with proper grouping no shore would be a safe landing place for an enemy.

A possible grouping arrangement is shown in Fig. 6[1], where 140 concrete bases have been theoretically located. It is

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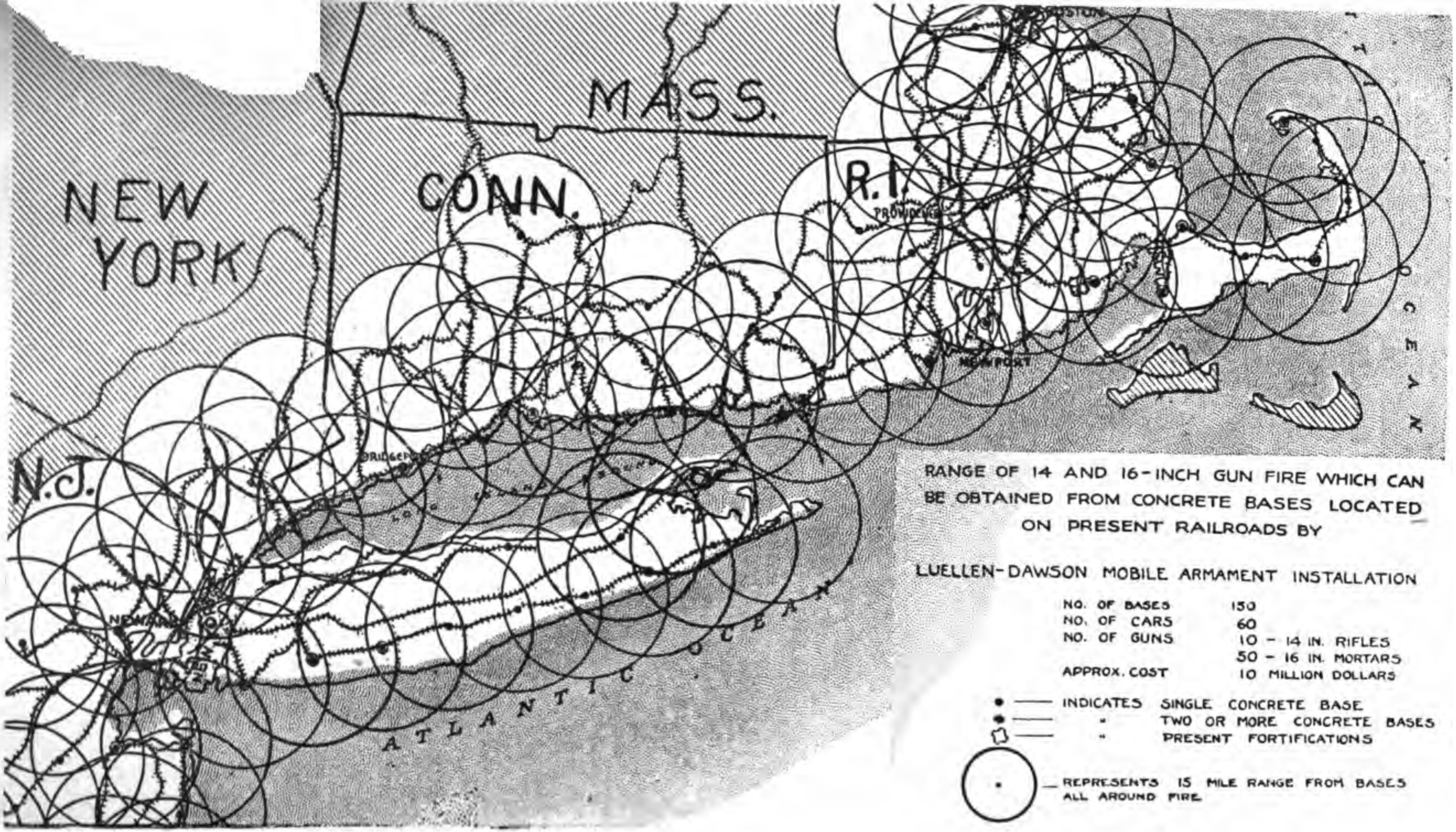
[1] Fig. 6 included the coast-line from Maine to Delaware. Due to its large size and to obtain a clear illustration, it was found practicable to reproduce only that portion shown.



RANGE OF 14 AND 16-INCH GUN FIRE WHICH CAN BE OBTAINED FROM CONCRETE BASES LOCATED ON PRESENT RAILROADS BY

LUELLEN-DAWSON MOBILE ARMAMENT INSTALLATION

FIG. 6.

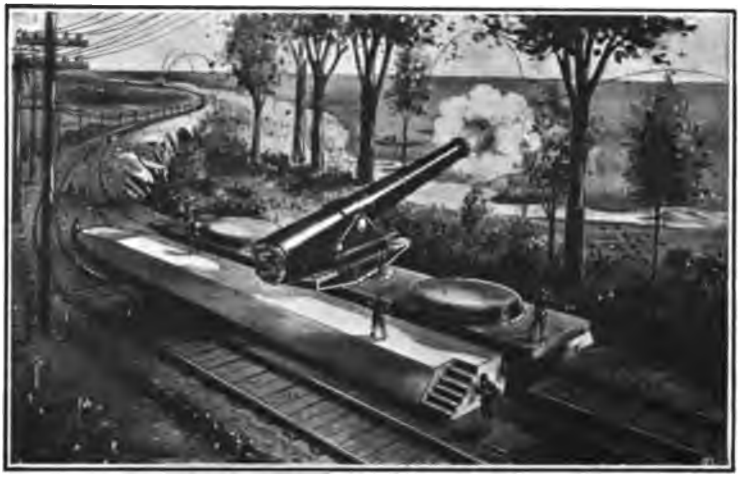


FIG. 7. 1991

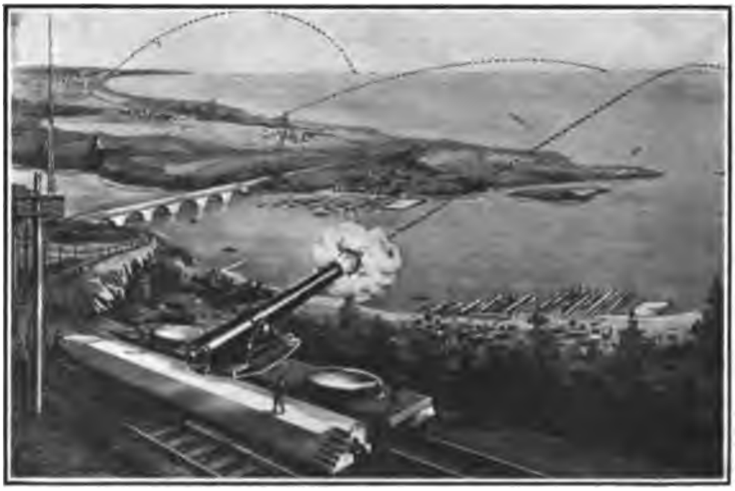


FIG. 8. 1992

estimated that an armament of fifty mortar cars and ten rifle cars could successfully cover the sector shown. This would afford a total of 110 guns and mortars when fully mobilized at any locality.

This number of concrete bases would cost approximately $500,000 or between $3000 and $4000 each, and with the armament suggested, that is 110 guns and mortars, the system outlined for the sector shown would cost in the neighborhood of $9,000,000.

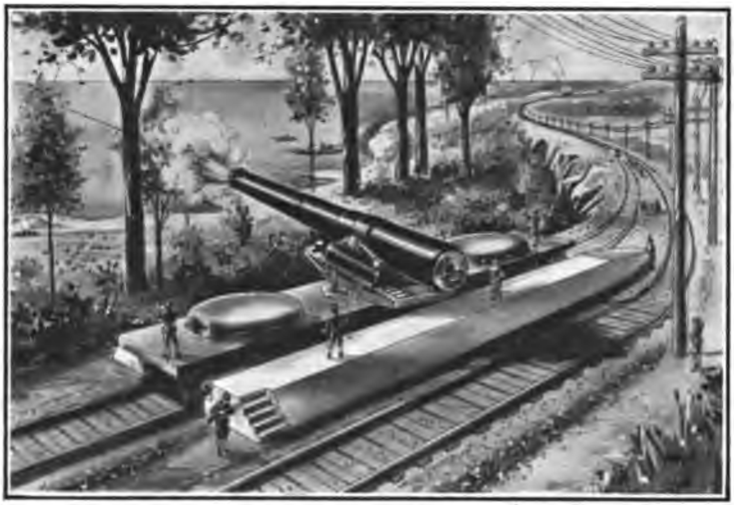


FIG. 9.

1993

Recently, expert naval constructors were asked to predict what might be expected in the way of super-dreadnoughts in the immediate future.

These figures were given:

Displacement........80,000 tons.
Length..............975 feet.
Beam................108 feet.
Radius of action....12,000 miles.
Speed...............25 knots.
Armament:
  Fifteen...........18-inch guns.
  Twenty-one....... 6-inch guns.
  Four..............21-inch torpedo tubes.
  Twelve........... 3-inch anti-aircraft guns.
Cost................$50,000,000.

Only casual consideration of these figures is sufficient argument for some system of coast defense capable of mobilizing heavy armament to offset an attack such as might be expected from fighting craft of even half the size and armament of the one described.

Many officers of the Coast Artillery Corps are of the opinion that the best form of mobile seacoast artillery is that which permits of firing directly from its traveling carriage, and this prerequisite does not seem impossible when considered in the light of what has been and is being accomplished abroad. Specially constructed spur tracks, or sidings, have many advantages over the permanently constructed concrete bases installed at predetermined positions which would undoubtedly be known by the General Staffs of foreign nations.

A system of mobile coast artillery armament would afford the following advantages:

1. It would afford a means of quickly mobilizing, at any point on our seacoast, sufficient heavy armament to repel an attack by any group of capital ships which might reasonably be brought against such point.
2. It would afford a means of reinforcing our harbor defenses.
3. It would afford a means of protecting cities, towns, harbors, and strategical points not now fortified.
4. It could be used, also, when necessary, to strengthen the more important points in our present land defense system.
5. It would afford a system whose location could be better concealed and whose exact location would not necessarily be known beforehand.
6. It would not require an excessive personnel; and no new methods of fire direction and control are essential.
7. It would prevent a convoying fleet from coming near enough to shore to cover a landing with its guns.

When it is considered that modern warfare is now conducted on the land, under the ground, on the water, under the water, and in the air, it is hardly necessary to remind anyone that these new elements of warfare have produced new conditions and problems to be solved. The old method of protecting only our principal cities and harbors by fixed fortifications no longer answers all requirements; and when it is considered that a suitable system of seacoast mobile armament will extend further protection to cities, towns, and harbors not heretofore protected, as well as denying favorable landing places to an enemy, the value of such a system becomes apparent.

ANTI-AIRCRAFT DEFENSES FOR COAST FORTIFICATIONS

By Major THOMAS Q. ASHBURN, C. A. C., U. S. Army

In the study of such a subject the first step is to determine what types of air-craft will be used, how they will be used, and what purposes they are designed to accomplish.

There are three conditions under which the defenses may have to contend with hostile air-craft.

1. When the fleet has a sufficient number to gain control of the air.
2. When the hostile air-craft are approximately equal.
3. When the air-craft of the defenses are powerful enough to control the air.

Under any and all of these conditions some one of the following objects is designed to be accomplished by the fleet air-craft:

1. To reconnoiter and discover the location of the various elements of the defenses.
2. To control the fire of the enemy's ships against land batteries and defenses, and hostile ships.
3. To bombard.

In these three objects three separate types of machines would probably be used:

For the first, scouting machines of the tractor type, quick acting, capable of a speed of 80 miles an hour or more, unarmored, unencumbered by wireless or guns, carrying not more than one or two passengers who are armed only with a rifle or revolver and provided with field glasses and photographic apparatus.

For the second, heavier and slower machines, capable of furnishing all necessary conveniences to the aviators, of great stability under slow speed, armored sufficiently to resist rifle attack, and fitted with sufficient armament to repel "scout" attacks.

The third class should be speedy, easily maneuvered, all steel covered (if practicable), capable of carrying sufficient guns to meet a destroyer on even terms, and equipped with bombing material.

In the discussion of any project for defense, it is wise to consider that the enemy has been able to limit the defense as much as possible, and to devise ends and means to meet such conditions.

If the lesser unfavorable conditions are actually what occur, so much the better for the defenses; and if the defenses actually gain the supremacy of the air, then a formidable menace is greatly reduced.

We will, therefore, assume that the enemy has gained control of the air, but that the defenses still have a few machines of all types available. This is really a fair assumption, because at the present time our aerial equipment is decidedly inferior to that of any powerful foreign nation, and while Congress appropriated liberally in the last year for aeroplanes, etc., and an organization into units has been started, it will be some time in the future before we can hope to cope in war times with a foreign invader.

Let us consider a defense against the scout type first.

What can a scout do?

No material damage; for it is a light machine, unarmored, easily handled, and rarely carrying more than two men. It can, however, do very substantial damage in locating the various elements of the defense if unmolested.

How close must they fly to the defenses to obtain accurate information?

Of course that will depend upon the condition of the atmosphere; whether or not there are clouds, rain, snow, or fog.

Colonel Bishop and Lieutenant Robertson flying at 10,000 to 3000 feet, were not able to distinguish whether a flat stretch of desert was or was not the Salton Sea. True, the air conditions were unfavorable. Under favorable conditions, the least limit to which the scout plane must descend is the distance at which the telephoto-lens cameras make pictures sufficiently clear to be enlarged so as to show the terrain conditions, or where the observer can distinguish clearly enough by his glasses to make a sketch. At the beginning of the war, photographs and sketches were made at distances from 500 to 2000 feet. The limit at which they are now made is practically 5-6000 feet, but may be as high as 8000 feet and perhaps more. The vision from air-craft, however, is greatly impaired by the slightest haze.

As the limit of the use of the scout has increased, the effective range of air-craft guns, and their handling, has more than kept pace, and today, according to an eminent English authority, and to our own Signal Corps reports, "the development of anti-aircraft artillery has reached a point where it is decidedly uncomfortable for an aviator to fly lower than 10,000 feet." The United States considers that the "safe" altitude is not less than 12,000 feet. The use of aeroplanes at night for purposes of scouting or reconnaissance are so confined that the question of defense against them at night is superfluous, except to keep under cover as much as possible and to use searchlights judiciously.

Let us now consider the destroyer class.

Their method of attack against seacoast fortifications is limited to bombing.

According to the very best authorities obtainable, drop bombs are classified as light weight, medium weight, and heavy. The light weight bombs vary from a few pounds to 15 pounds, the medium weight from 15 to 50 pounds, and heavy bombs, which go no higher than 100 pounds in our service, may range as high as 220 pounds. In a few isolated cases bombs weighing as high as 400 pounds have been used. These bombs are undoubtedly designed to detonate upon impact and, while good reasons can be advanced for equipping them with time fuzes that would be ignited by the shock of impact, there would be the objection that the bomb would have to be heavier in order to have sufficient strength to resist breaking up on striking and before explosion could take place.

These facts, however, have probably caused the bomb makers to invent a combination impact and time fuze for, of course, the heavier the bomb, the more difficult it is to handle in the aeroplane and also the smaller the number that can be carried.

Everyone has seen an acrobat in a circus drop from the top of a tent into a net, from distances of 50 to 100 feet. The acrobat is thrown up in the air a distance having a direct proportion to the distance he has fallen. It would be an interesting experiment to try a series of rope or wire nets, separated by, say, a foot or so apart, and drop weights, corresponding to bombs, upon them from different heights to see if a series of three or four nets would not stop the weights. If it were found that these nets were capable of stopping the weights, then real bombs fitted with detonators could be tried to see if the bombs would detonate. If the experiments showed that they were successful, all gun emplacements of sufficient importance and other important elements of the defense might be protected from a direct hit by some such means as that suggested.

This proposition may appear absurd on the face of it, and it is not substantiated by any mathematical argument. Nevertheless, the fact remains that there is no case of which there is any record of bombs having fallen in accordance with the theoretical law of falling bodies, or in accordance with preconceived ideas. The very shape of the bomb, the fact that it has to pass through air strata of varying degrees of resistance, the fact that the thoeretical law itself may be wrong, certainly leave room for experimentation. Laws deduced by actual experience may safely be assumed to be correct, but who, before the invention of aeroplanes and actual bomb dropping, even had a chance to more than theorize in deducing a law for falling bodies?

The United States military authorities state positively that bomb dropping at altitudes of 6000 feet cannot be carried out with any degree of accuracy. As long as aerial raids can be kept at higher altitudes, they cannot be considered as a serious menace to fortified works. The question for the defense is, then, to provide means of keeping them at least 6000 feet up in the air.

The problem offered by the "spotters" is, however, a different one. They will climb sufficiently high and sufficiently far away from the guns, if possible, to be safe. If they are amply protected by destroyers and scouts, the question of their destruction does not seem to be a serious one. They must be accepted, under the conditions assumed, as a disagreeable factor to be reckoned with, and efforts will be made to keep them as far away as practicable. If they can be kept at 10,000 yards, then spotting will be exceedingly difficult for them; and, due to the film of smoke which will arise from the shore guns and any haze that may be over the ground, it may safely be assumed that if their spotting is to be of any value, they must be at least within 6000 feet of the striking points of the shells.

In order to determine upon the type of guns to be used in anti-aircraft defense, we have now to consider what will constitute effective hits on the air-craft of the various types discussed.

Shrapnel, or small arms fire, will only give effective hits when they strike the personnel, gasoline tanks, delicate parts of the motor, the propeller, and controlling parts of the mechanism. The Studevant people have constructed an all-steel battle aeroplane in which the motor, the controlling parts of the mechanism, the gasoline tanks, and the personnel are pretty well protected against such hits. Abroad they use calibers approximating 75 mm., and they use both shrapnel and high explosive shell with time fuses. These shell or shrapnel must make direct hits on the parts mentioned to wreck the machine.

The detonation of a medium-caliber, high-explosive shell within 100 feet of an aeroplane might cause the plane to dive or capsize, but would not necessarily wreck the machine. Aeroplanes have landed safely within their own limits with as many as 400 holes through the wings and fuselage.

The ordinary machine guns, such as the Benet, Lewis, etc., the latter of which is largely used abroad, do not use ammunition varying much from the ordinary .30 caliber used in the Springfield small arms. The data available for the Springfield will therefore give us a standard of comparison. The maximum vertical range for small arms has been determined to be approximately 10,000 feet, and at 4000 feet the striking velocity is only some 900 feet per second. We may therefore rest assured that air-craft are fairly safe from machine gun or rifle fire at 4000 feet. They are effective at 6000, so we must have something more harmful to use in firing at them.

The Ordnance Department has determined that a 3-inch, 15-pdr., having the same general construction and ballistics of the 15-pdr., model of 1903, with a 7-caliber ogive, will give a maximum altitude of 30,000 feet when using a muzzle velocity of 2600 feet per second. The higher the altitude, the greater the muzzle elevation and the more uncertain are the elements which enter into the ballistic computations.

It is a well-known fact that the velocity of the air varies at the same place in different strata; and while in big gun practice, we assume a constant vèlocity and direction of the wind, it is only because the shell from a gun travels in the same stratum. As soon as mortars are involved the variations due to different strata through which the projectile passes introduce some curious results. It is impossible to deduce a rule, because the variations of strata in one day are different from those on another. Some very interesting models are shown on page 235 of the JOURNAL U. S. ARTILLERY for September-October, 1916, illustrating the different velocities of air at different levels at the same vicinity. However, these problems must be met, and are being met by the ballistician and mathematician, and several rules of thumb have been deduced for approximating the height of an airship. We assume, moreover, that the Ordnance Department has a reasonable range finder, and accurate setting device, when they announce that the "safe" elevation is at least 12,000 feet.

There is an advantage, also, to the defenses in the fact that their aeroplanes are not burdened with drop bombs, can climb faster and out-maneuver the raiders who may be forced to drop their bombs prematurely in order to get away safely. Thus, if the defenses still have a few air-craft left, they may be used very advantageously.

If the raiders succeed in getting well within the effective limit of bomb throwing, then they must be attacked with machine guns. They are liable to do so, and it is evident that the defenses must have machine guns capable of being fired at any angle and from any position.

We must keep the scouts and destroyers at least 6500 feet away, if possible, and if they still continue to sweep down, to attack them with machine guns.

What means of attack by guns offers the best chance of success?

Evidently by directing a group of shots ahead of the target, calculating to create a dangerous zone through which the air-craft must fly.

The common analogy of shooting at a flying target will give us some idea of the arrangements to be adopted for the anti-aircraft guns. One does not shoot at a flying duck with a rifle with any chance of success, but with a shot gun. The ideal gun to shoot at air-craft would be one having all the capabilities of the gun above described, i.e., the 3-inch, 15-pdr., but discharging a flock of shells from approximately the same place. Such a gun of medium caliber is not yet invented, nor does there appear to be hopes for one, but the distribution of the 15-pounders in such a way as to simulate this condition, is approaching the ideal. Experience has proven that the best unit is a four-gun battery, each gun at the corner of a 200-feet square and having a director in the center.

The next condition is that these groups of batteries should be mutually supporting, again approximating the shot-gun idea. They should not be too close to the object to be defended, for three reasons: one of which is the danger of their being struck by a stray bomb directed at the battery they are defending; the second is, that as the air-craft approaches its object, the higher must be the elevation of the guns to hit the target, and the less accurate the fire; and the third is, that the smoke from the heavy guns will afford the aviator the means of spotting the anti-aircraft guns, and may lead him to attack them instead of the original object.

The guns, should, if practicable have an uninterrupted view of the horizon in all directions. The range finder and director being in the center of the battery makes this nearly mandatory.

It should also be remembered that there will be no time for relocating against air-craft traveling 60 miles or more an hour.

A consideration of the above induces us to believe that the following should be controlling principles in locating the anti-aircraft emplacements containing the 3-inch (15-pdrs.) and the machine guns.

a. The most effective fire and fire control will be obtained by locating the guns in groups of four, each gun at the corner of a 200-foot square with the director at the center.

b. To attack effectively, the hostile airplanes must be at an altitude of 6000 feet or less and approximately over the object being attacked.

c. The emplacements should be so located as to prevent hostile airplanes from reaching the position indicated in par. (b), *supra*, and should be able be bring a converging fire on any airplanes that are successful in attaining that position.

d. A single gun or group of guns defending any point, should be, when practicable, at least 1000 yards from that point.

e. The emplacements should be mutually supporting.

f. If practicable, the guns should have an uninterrupted view of the horizon in all directions.

g. Other considerations being equal, the emplacements ould be located on government reservations.

h. Machine guns in groups of four or six should be located ry close to the positions to be defended.

These anti-aircraft batteries should be controlled by an officer (director) stationed at the center of the battery, assisted by the necessary enlisted personnel, and the batteries should be organized into higher units, composed of those batteries which are mutually supporting. As these batteries are designed to protect certain elements of the defenses, the commander of the elements which they protect should also be the commander of the unit into which the groups are organized. The same general supervision exercised over the other elements of the defense by the coast defense commander, should be exercised by him over the anti-aircraft defenses.

THE SCIENTIFIC AND ANALYTICAL STUDY OF MILITARY HISTORY

By Captain HOWARD L. LANDERS, C. A. C., U. S. Army[1]

Why Military History Should Be Accurately Written

The Military History of the United States has been written with but little regard either for a correct analytical study of our national wars, or for a scientific observance of the rules of evidence that must be used in testing all material considered by the historian. Our national history "should be written and taught so that our future statesmen and legislators may not grow up with distorted views of our military prowess or in ignorance of the influence of military strength upon our future position in the family of nations. The truth about all our wars should be told and military events should be shown in true perspective."[2]

Without such a study a military policy possessing inherent and permanent strength cannot be formulated, nor can we train our military and naval forces to that high degree of efficiency which it is our ambition to attain.

One of the most valuable features in the curriculum of the Service Schools at Fort Leavenworth is the course in Military History, beginning in the School of the Line and covering the entire year in the Staff College. It is based on modern scientific methods, and in the opinion of the President of the Army War College "it is today the best course in Military History in the country."

Historical Section of the General Staff

The General Staff of all European powers has an Historical section for the preparation of technical military histories. In our army that section has not been formed as the personnel is not yet available, but it is being developed and a home is already prepared for it at the Army War College. "Our General Staff at present has no way in which it can reach the public or even the army in friendly discussion."[1] A step in that direction was taken two years ago by the issuance of Official Bulletins, but they cannot fill the place of a Staff Journal. "Such periodicals have been found a necessity in European services, and they are generally issued under the auspices of the Historical Section of the General Staff."[1]

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[1] Lecture delivered at the U. S. Naval War College, October 9, 1916.

[2] General Macomb, President of the Army War College, in an address to the New York State Historical Association at West Point, October 7, 1915.

The Study of Military History in Our Service Schools

The scientific study of history in our military schools received its initial impulse in 1907. It was then recognized "that the study of the Art of War, in time of peace, rested upon the study of actual occurrences in the past; and that, as we get beyond the few simple rules for the tactical handling of a small force, we can only judge the future with confidence when we know the past with certitude."[1]

In the organization and development of the new course in Military History the school authorities secured the advice of Professor Fred Morrow Fling, of the University of Nebraska, "well known as one of the foremost authorities on Historical Method in the country."[1] Many of the ideas contained in this paper, and much of the text, are from several books written by Professor Fling in collaboration with others: Studies in American and European History, published in 1897 and Source Problems on the French Revolution, published in 1913.[2]

Psychological Value of Historical Method

The benefit derived by the student in following the tenents of Historical Method is in no wise limited to the acquisition of certain historical facts and the enlargement of his knowledge of military affairs generally. There is also developed within him capacity for independent thought and subconscious reasoning that can be acquired in no other way. You are familiar with the psychological expression, "Fog of War"—

> That maze of half-information and misinformation which always surrounds the commander in war. This fog of war makes obscure not only where the enemy is, what he is doing, but the very data concerning the ground, and concerning our own troops. It is in this haze that the com-

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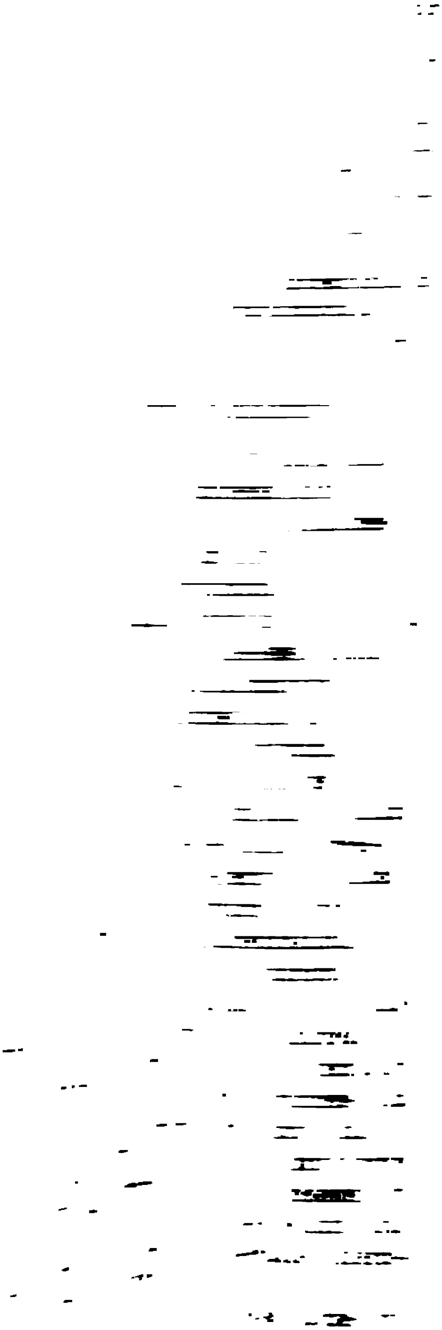
[1] See footnote 2, page 174.

[2] Another interesting guide to consult is "Introduction to the Study of History," by Langlois and Seignobos, first published in 1898.



spies and cavalry screens, is now augmented by the use of armored cars dashing through the enemy's advanced positions and obtaining their security by carrying with them strong infantry units.

The machine gun, in both numbers and tactical handling, is replacing in great measure the rifle and is making the foot soldier a more dangerous enemy than ever before.

Artillery is massed in size and numbers never before dreamed of, and a nation that cannot provide for it an endless stream of ammunition will go down to defeat.

Trench warfare has assumed an intensity that racks the souls of men; the training of a soldier now makes it necessary to remake the man, mentally, physically, and spiritually so that when the call comes to sacrifice not only himself, but his entire battalion, he will respond to it knowing no thought other than to submerge his individuality into the mass and go forward to complete annihilation under the will of his leader.

The scouts, cruisers and battleships of the air each performs a function of aerial warfare as distinctive as that done by the motor-cyclist scout and the 42-cm. gun.

The use of bombs, liquid fire, poisonous gases—*we know* nothing of this kind of warfare.

Massed formations, one wave following close upon the other—facing a storm of fire which the Battalion knows will exterminate it, but still going forward to do what it may and to that extent make possible the successful advance of the battalions which follow—what personal knowledge have we of such attacks?

How are we to learn what this war teaches? Who will do the work of studying the mass of information already at hand? It is too stupendous a task for a handful of men to undertake. Don't let us be content to have others do our researching for us. Each of us can find the time to do a certain amount of independent reading and study. The power to read intensively must be cultivated; to know how to find the underlying truth, and then to build up a creative structure that will be the product of one's own intellect.

Historical Method

The guiding principles upon which the teachings of Historical Method are based are no more difficult of comprehension than are the rules of evidence. It is necessary to keep constantly in mind the thought that your efforts are directed essentially to a determination of what are the facts in the case, as established by an impartial and critical analysis of the source material at hand. Historical Method is the guide whereby the student acquires the facility to logically interpret and coordinate these sources.

In the teaching of History it has generally been accepted that a satisfactory method was to have the student memorize as much of the contents of the book as his mental capacity made possible, and accept as true the deductions and conclusions drawn by the author. It was thought that this instruction could be imparted by anyone who had the opportunity to read the narrative in advance of the student, and acquire a sufficient knowledge of the contents of the book to readily answer questions and to coordinate the daily lessons. This method of imparting instruction in historical subjects has been accepted with but little question from time immemorial, and it is only in recent years that the idea has been developing that History is a constructive science as much as is Chemistry or Physics.

HISTORY, THE SCIENCE OF THE EVOLUTION OF LIFE

Bernheim defines History as "The science of the evolution of man in his activity as a social being." The broad application of this definition covers not only the history of mankind since the creation, but includes also a knowledge of his physical and geographical environments in all parts of the world. Such an extended application of the subject is beyond the purpose of this paper. As citizens of the United States, we are more directly intersted in the history of our country, including a knowledge of such antecedent events as may be necessary for a better comprehension of our racial and social evolution, and of such collateral events of other nations as may be necessary to correctly interpret the significance of any occurence in our national existence, or to account for any phase or development of our political or economic life. As military men, we are particularly interested in the study of warfare—three years ago I would have said "of modern warfare," but the events of the past two years have shown such a reversion to the methods of centuries ago, that we may well believe that while there is much that is new in war, still it is unsafe to forget and eliminate the crude methods of past ages.

OF HISTORY IN MILITARY AND OTHER SCHOOLS

ools there should be taught a combination of nches of History. The instruction to the High nts would be largely elemental, while in the universities its expansion could be carried to any might be desired. In the Army the instruction primarily the period of the Civil War, and then k through the other wars to our first conflict with

n these limits, then, it is to be hoped that the initial ion to this subject may be so simplified as to make that he is approaching a course of study not unduly , or beyond the possibility of devoting to it a reasonnount of time, from which favorable results may be ed. If you will keep in mind that it is not intended ocate that officers in general devote a great amount of to the study of a mass of historical matter, but merely oint out the analytical method in which any historical should be undertaken, no matter how small, until a wledge of the method is understood and appreciated, then subject at the outset will present fewer difficulties.

Nor is it to be expected that we can lay aside for some time e narrative history as the basis of our knowledge of historical vents. In the study of other sciences a certain amount of aboratory work is done by the student body wherein is demonstrated to their satisfaction the correctness of principles already established, while many other conclusions contained in the text-books are accepted as true, or probably so, without further experimentation. In the *study* of history, as the word *study* has generally been interpreted in the past, we have accepted as true the conclusions drawn by the author of the text, and even where we have doubted the correctness of his deductions, it has been easy to excuse further research into the subject by saying that probably he knew as much about the matter as did another writer.

HISTORY, AS A SCIENCE, COMPARED WITH OTHER SCIENCES

But we find this great difference in the preparation of text-books on History and on the other sciences. Histories are not written with any degree of accuracy—the deductions drawn in many cases are based upon an inexact presentation or analysis of the basic material. We have scarcely any history of which it can be said that it presents a correct picture of the events as they actually occurred. And indeed such a writing is most difficult of preparation. Each participant in the smallest affairs of life has his own individual recollection of those events which differ from those of his neighbor, and no two accounts will agree. But this fact introduces no new complications into the matter. It is a principle which has been recognized at all times in law, that the testimony of two participants in an affair will never agree as to all the details, otherwise there would be but very little occasion for a judge or jury to exercise its usual function of weighing evidence and determining what did, and what did not, occur.

So the science of History is not so much like the study of one of the exact sciences, where the experiment of today may be reproduced a thousand years hence, as it is like the study of law, which has to deal in every case with a separate combination of events that cannot be reproduced. We deal in History with events that are past. The record of those events may live in numerous ways. Witnesses may recount the events, documents may narrate what the writer knows or has heard of them, remains of the period may be at hand to help interpret what occurred, and in many other ways will knowledge, more or less accurate, be carried down into the future and furnish the material upon which the historian must build. And it is this method of reconstructing the past that it is desired to make clear so that you may know how, first, to analyze and determine the value of the evidence, then from the facts which have been established, to build up a connected narrative which will portray the events of the past, based upon proof represented by the best evidence obtainable.

Sources—Remains—Traditions

There is but one way to reconstruct the *Life* of the past and that is from the *Remains* of the past. Everything that has come down from the past must be used in reconstructing its historical picture. These remains are called *Historical Sources*. As the word "History" is applied indiscriminately to both the fact and the record of the fact, it is of the utmost importance that at the very outset we draw the line sharply between the two. The historical past is all that actually did happen in all its fullness and truthfulness; the record of the past is the belief of certain persons as to what happened. It is quite evident that the past and the record of the past may be very different things. In truth, they generally are quite different and can never be exactly the same. If this last assertion be correct, then we can never know exactly what happened at a certain time and in a certain place, and absolute historical truth is beyond our reach.

In the case of a battle we study the reports of the various commanders; we search their diaries and letters; we interrogate survivors; we read the dispatches of generals and the writings of observers; we study the battlefield, the arms and the equipment, and the resources of both combatants. In short, all material is collected that can throw any light upon the event itself and help us to restore it. The sources may be classified as follows: *Material Remains* and *Traditions.*

Material Remains are all of those things that are actually part and parcel of the life of past generations; bodies of men, clothing, weapons, buildings, roads, bridges, newspapers, letters, coins, etc.

Traditions are of three kinds, *Oral, Written* and *Pictorial.* Oral, such as stories, anecdotes, songs; written, such as reports, chronicles, biographies; pictorial, such as statuary, pictures, sketches.

External Analysis of Source Material

But when the historian has collected his material he has taken only the first step. The material must be tested and its value determined. It must be known, first of all, if it is genuine, that is, if it is what it pretends to be. The analysis to which the source material is now subjected is of two kinds, *external* and *internal.* The former deals primarily with the admissibility of the documents as evidence; the latter with its credibility.

Considering now more fully the meaning of external analysis, the first question asked is whether or not the paper, record or remains is genuine. The second is, has there been self-deception in the interpretation of the source whereby wrong deductions have been drawn by the historian.

Man is naturally credulous. It is much easier to believe what is heard than to sift the evidence in order to find out the truth. A long list of forgeries can be presented which have been made under the head of Remains. The practice of fabricating relics and, for various reasons, passing them off as genuine, has been continued down to our own day. Two of the most famous of those perpetrated in the nineteenth century are described by Bernheim: the first was the Moabite

Pottery, the second the Sardinian Literature, or parchments of Arborea. The Moabite Pottery has been shown to be counterfeits. The Sardinian forgery was exposed by investigating the material of the manuscripts; studying the style of the handwriting, the language and literature of the contents; and by checking up the historical data referred to in the papers.

In 1895 a work entitled, "The Journal of a Spy in Paris During the Reign of Terror," purporting to have been written in 1794 by one Raoul Hesdin, was printed in London by the reputable firm of John Murray. In the following year the English Historical Review was able to prove by a study of the contents of the Diary that the book was a forgery. It was through his knowledge of later events that the writer of the Diary fell a victim to the critics.

GENUINENESS OF THE SOURCE

The investigation of the genuineness of a source is little more than a series of comparisons systematically conducted. The source material under analysis forms a part of the Remains that have come down to us from some previous age. If it is genuine it will be in harmony with all the other sources of that period and bear the marks common to all the products of learning of that age. It is this fact which makes it difficult for a forgery to escape detection if the critic has an adequate knowledge of the period concerned. But few individuals possess the rare skill to successfully imitate the language and writing of past ages, to the extent of being able to deceive the trained critic.

LOCALIZATION OF THE SOURCE

If the Source Material stands the test and is clearly genuine, the historian takes the next step in External Criticism by attempting to localize the Source, that is, to tell when the account was written, and who the author was. When these questions have been answered the Source has been localized, and the historian knows whether or not it may be admitted as evidence. The further question as to what this evidence is worth is dealt with under Internal Criticism.

It is evident that the work of localizing the Source is closely connected with that of determining its genuineness. If the document is genuine, and the name of the author, the time and place of writing, are all given, there is no need of an investigation. A distinction should be made, however, between the time of writing and the time of printing, the place of writing and the place of printing, the author of the title page and the real author. If these two sets of facts always agreed, the work of investigation would be rendered much easier.

ANALYZING THE SOURCES

The work of External Criticism is not completed when the source has been shown to be genuine and has been localized. It still remains for the student of history to analyze his sources and, in some cases, even to endeavor to restore the printed or written text, corrupted by copyists.

The need of text analysis is self-evident. In the first place, all the events recorded by a witness have not, as a rule, been directly observed by him. Not all parts of his record are equally valuable and the first-hand evidence can be separated from the derived only by analysis. In the second place, as we shall see later, historical facts are established by the agreement among *independent* witnesses. It is of the first importance, then, that the independence of the witnesses should be established, and this is done by studying the relation of one source to another. I shall consider, then,

1. The analysis of a single source.
2. The analysis of the relationship existing among several sources.

INDEPENDENCE OF WITNESSES

Failure to analyze their sources and to distinguish between what the witness knows first hand and what he has derived from others is one of the characteristics of the uncritical historian. Having decided that the work as a whole is genuine and that it was written by a contemporary who lived in the midst of the events described, the general inference is made that all the evidence contained in the record must be source material. That is, of course, as a rule a false inference, but it is surprising how long it has taken historical science to get beyond it. The best way to exemplify this is by considering our Civil War Records, and the historical references to them. Almost invariably writers accept as their sources the reports of the Commanding Generals or Corps Commanders, when in reality but little of the contents of these reports is primary evidence, but is built up from the reports of the smaller commanders. The regimental and brigade commanders usually report on what they see and know; the division and corps commanders compile most of this information and include it in their reports, hence the historian must analyze the text of these reports and determine what part is primary evidence and what is taken from the reports of others.

We now have to consider the relationship between sources. The testimony of two or more eye-witnesses is sufficient to establish a fact, but on the condition that the witnesses are independent of each other. The failure to meet this condition is a common occurrence. Students appear to think that a fact is established by a number of references in support of it, the question of independence being entirely overlooked. They do not stop to consider the fact that if four references to an event are found and three of these four draw their information from the fourth it is sufficient to give only the one reference; it does not strengthen the case to add the remaining three references. It is of common occurrence to find in the Rebellion Records a statement made by a regimental commander of some notable action of his regiment, which is carried almost intact to the brigade, division and corps reports.

In determining the independence of the sources, the following psychological axioms must be borne in mind:

1. When two individuals perceive the same event, they neither seize upon the same details nor report them in the same way.
2. When two individuals give expression to independent conceptions, they never make use of exactly the same form.

From these axioms, we draw the inference that if two or more sources report the same facts in the same or nearly the same form, these accounts have not been independently conceived. Where the statement of facts is made by a single witness, the value of the evidence will depend upon the general character of the witness and the way in which his evidence harmonizes with our general knowledge of the period. Where facts are stated by several witnesses who disagree, the evidence of the most reliable witness must be set over against the least reliable, the evidence of the unreliable being, at times, rejected altogether.

RESTORATION OF ORIGINAL TEXT

When the source is known to be genuine, has been localized, and the text analyzed, it only remains to restore the original text of the document and, if it be a manuscript, to prepare it for publication. This completes the External Criticism.

The necessity of a carefully restored text is evident in the case of classical and mediæval manuscripts. It is much less frequently a factor of importance when dealing with later documents. The necessity for such work is due primarily to the carelessness of copyists; also to the difficulty of deciphering certain handwriting or to understand the construction and meaning of certain words, phrases, and sentences. An interesting example of this is the use made by Longstreet of an extract from the Rebellion Records.

In volume XI, Part 3, page 563, is printed an order from Johnston to Smith, containing the words "(Gaines?) road." This method of printing indicates that the compiler was uncertain as to the correctness of the word "Gaines." In later years, Longstreet, in order to defend certain action during the Peninsula Campaign, quoted this order from the records without showing the uncertainty as to the word "Gaines," and on the strength of it put on a map a road which was not in existence. (Longstreet, pp. 89, 96.)

Internal Analysis of Source Material

When the original text is restored, the work of External Criticism is finished and we are ready for Internal Criticism. In other words, we have decided what material shall be admitted as evidence; it now remains to be seen what that evidence is worth and by means of it to establish the historical facts.

In making the Internal Criticism it will be well to adopt the following subdivision of the work:

1. Determination of the Value of the Sources.
2. Interpretation of the Sources.
3. Establishment of the Facts.

DETERMINATION OF THE VALUE OF THE SOURCES

Although each fact must be examined by itself to determine its worth, it is necessary first of all to form a general estimate of the value of the work from the character of the source and from the individuality of the writer. It is just as legitimate to do this work before taking up the formal interpretation of the source as it is to deal with the problems of External Criticism before the source has been carefully interpreted.

The value of the material in a source is determined by three things:

1. The Character of the Source.
2. The Individuality of the Writer.
3. The Influence of Time and Place.

Newspapers may express the views of a political party and sometimes the sympathies of a nation, but as true records of events they may be of little worth. Stories of Civil War happenings are still recounted around the campfire by those who participated in the events narrated, but how little dependence can be placed in the correctness of these tales.

When we come to consider the *Individuality of the Writer* in determining the worth of the source, we are considering the most important factor in judging the value of written Tradition. For written Tradition is nothing more than the record of some person's conception of an event. The value of the conception depends, very clearly, upon the personality of the witness. The information which the historian requires concerning the witness is of two kinds, intellectual and moral. Was he able to observe carefully and to describe correctly what he saw? Was he desirous of seeing the truth and of telling the truth? To answer these questions satisfactorily the historian must know what the birth and education of the witness was; in what class of society he moved; what his occupation had been; what special training he had had that fitted him to observe these particular facts and what opportunities he had for observation. These would be the intellectual requirements touching his ability to tell the truth. There are other requirements that are partly intellectual and partly moral. Were his prejudices and passions so strong that he would be unable to see the truth or that he would unconsciously misrepresent what he saw? In connection with his moral fitness, the historian must know whether or not the witness is an honest man; whether he was filled with a desire to know the truth and when he knew it, whether he would consider it his duty to tell it.

INTERPRETATION OF THE SOURCES

Having formed a general estimate of the Value of the Source, the historian proceeds to interpret it. He must be able to interpret the writing of the documents employed. This does not mean simply ability to read the letters, but to interpret abbreviations correctly and to understand all the peculiarities of the record. The interpretation of the language demands a knowledge of the words used at a given period, and an understanding from the context of the different ways in which the same author uses the same words in different places. It is not an uncommon thing to discover that the references given to support a statement have quite a different meaning when studied in their context from what they have when isolated. The historian must so reconstruct the conditions of time and place that the document will appeal to him as it appealed to a contemporary. He must endeavor to put himself in the place of the writer.

ESTABLISHMENT OF THE FACTS

We have now reached the end that historical criticism has ever in view—the establishment of the Historical Facts. The determination of the genuineness of the sources in hand, their localization, and analysis, are of value to the historian only so far as they enable him to decide whether this material may be admitted as evidence. The determination of the value of the sources as a whole and their interpretation simply make clear to him the general reliability of his witnesses and furnish him with their conceptions and affirmations concerning the subject under investigation. But what is the relation of these conceptions and affirmations of witnesses to what actually occurred? To answer this question is the last work of Internal Criticism. The material drawn from the sources is divided by Seignobos into two natural groups: *Conceptions* and *Affirmations.*

A Conception is Established by a Single Source

The testimony of a single source is sufficient to establish the existence and character of a conception. If a Commanding General writes to the Secretary of War—"I am unable to advance my lines as the enemy is threatening my right flank"—this statement alone establishes the conception of the situation held by the Commanding General. Sometimes this evidence, while technically correct and admissible, has to be ignored, for the statement may be a deliberate misrepresentation of the situation in order to accomplish some ulterior motive, as where a commander reports—"The enemy is in front of me in greatly superior strength and I cannot advance until reinforced." Reports of this nature are to be found in the Civil War records where at the time they were made the officer knew he was exaggerating the strength of the enemy on his front for the purpose of frightening the government into sending him more troops.

An Affirmation is Established by Two Sources

The affirmation of a single source concerning an external fact is never sufficient to extablish that fact. When two or more contemporary (eye and ear) witnesses report independently of one another, the same fact with many like details that do not have a necessary or usual, but rather a casual connection with the fact, then the accounts so far as they agree must be true, if the fact and its details were so clearly perceptible that no self-deception could have been possible. Where we have to deal with contradictory affirmations and the evidence of each writer is equally reliable, there is as a rule but one thing to be done—the historian must suspend judgment and announce that he can reach no definite results.

GROUPING OF THE FACTS AND CONSTRUCTION OF THE NARRATIVE

Having now fixed the facts and interpreted them, with these processes the critical or analytical operations are brought to an end. The second or synthetic stage is at hand, and the historian is ready for the constructive work of combining these interpretations so as to obtain a view of the whole subject. The combined result must be illumined by phantasy, which, working upon the results given it by criticism, interpretation and combination, endeavors to see the events in the form in which they happened. It is not with the imagination playing freely that we have to do here, but with the phantasy dealing with definite data. Where the phantasy is defective the highest results are not obtained; where the imagination is uncontrolled the results are unscientific and often worthless. Phantasy as here used means the ability to restore the historical past from definite data without doing violence to that data.

The field of Historical synthesis is largely unexplored territory, and this is particularly so of Military History. That is why so many writers, laying no claim to historical or military training, write so-called military narratives, which find acceptance on account of their personal or literary, but not on account of their scientific qualities.

One of the most difficult questions that have to be answered in this synthetic stage is as to the grouping of the facts; whether to follow a logical, geographical or chronological order. You can best understand what is meant by this if you imagine yourself called upon to formulate a system to be adopted in preparing a narrative history of both sides of the Civil War.

In letting the phantasy work it will be well to control it by keeping in mind the following suggestions:

1. Never mix up reasoning with the analysis of a source.
2. Never confound the facts drawn directly from the sources with facts obtained by reasoning.
3. Never reason unconsciously, but put the argument into logical form and the fallacy is easily detected.
4. If there is the least doubt about the soundness of the reasoning, draw no conclusions of a positive character.
5. Never attempt to turn a conjecture into a certainty by dwelling upon it.

Records of the Civil War

It will be well now to bring your attention more specifically to the work which it is desired that our army and navy undertake—the study of the Civil War and an intelligent reading of the events of the present world conflict. Congress has done something unprecedented in placing before the public, not only of our own country but of the world at large, the records of our Civil War. For no other records of conflicts in the world's history afford such an exhaustive collection of such material. The work of the student is greatly simplified for he finds no occasion to engage in much External Criticism. We accept the documents as they are found in the records, and it is only in isolated cases that we feel it would be desirable could reference be had to the original manuscript.

Much difficulty will be encountered at first in familiarizing oneself with the contents of these records. The work should be undertaken under the guidance of someone who is able to direct the first steps of the student, otherwise so much time will be consumed, needlessly, as to discourage the beginner. Many volumes of these records have documents appended in the back, and a list of typographical and other corrections in the front of the book. Some books marked as containing Correspondence also contain Reports. Many orders of importance from the War Department to the Commanding Generals in the field are omitted in the chronological arrangement of the correspondence and included in the several reports of the Commanding Generals. Documents are published in volumes 107 and 108 that cover the entire period of the war, and these books must always be consulted.

In Series II, III and IV are frequently found papers or communications that the historian must make use of in his study. Furthermore, it is well for the student to know exactly what the "*Rebellion Records*" are and the manner in which these volumes were compiled. There is appended to this paper a comprehensive review of this work which was extracted from the preface to the General Index, Serial No. 130, prepared by Elihu Root, Secretary of War, August 22, 1901.

The care with which these volumes were edited, and the insistence that communications be printed as originally written, make it possible for the student to accept this source material without the necessity of subjecting it to external criticism. A uniform style of composition was adopted, and this necessitated certain unimportant departures from the original records in such minor items as spelling, punctuation, abbreviation, and capitalization, but these changes were merely typographical.

But in considering the internal criticism of these sources the situation is quite different. The student must eliminate his natural but credulous belief in the accuracy of all facts which may be stated in military reports, and conduct his research with an open, impartial mind. After but very little study his attention will be brought to a conflict of statements that, as a soldier, he might have thought it impossible for military men to make.

> No sooner is the event past than the distortion of the details of it in the narrative begins. This subordinate seeks to claim for his command the credit to be given by history; that one does the same. In case of defeat each seeks to show the other was to blame. A command breaks and flees panic stricken from the field. The fact is hushed up if possible; otherwise it is condoned by excuses. The ammunition gives out, the neighboring command gives way uncovering the flank, an order is misunderstood or some equally fatuous euphemism. The student who wishes to know the actual cause of the break and the facts covering it, has a difficult task to penetrate the mass of lies and evasions written concerning it.[1]

USE OF MAPS IN READING HISTORY

In studying Military History, even when doing the most casual reading, use the best maps obtainable, otherwise the mental impressions gained will have no lasting qualities. No man's perspective of his own or any other country is so comprehensive that the brain picture can be depended upon for accuracy. Some forgotten valley or mountain range; some highway overlooked; some unthought of railway line or harbor might have untold effect in clearing up a situation the strategy of which would otherwise be unintelligible.

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[1] See footnote 2, page 174.

Many excellent maps of Europe have been published recently by the Service Schools on a scale of fifteen miles to the inch and larger that should be in the hands of all students of European war. The hydrographic charts published by the Navy are necessary—not only in studying naval strategy and combat, but to obtain a more comprehensive knowledge of those land operations which are conducted in close contact with the sea.

When engaged in a study of the Civil War, the topographical sheets on a scale of about one inch to the mile are invaluable. A series of these sheets covering from Richmond to Gettysburg can be mounted in several maps, and the student will always have at hand for tactical reference an actual picture of the terrain over which McClellan, Grant, and others fought Lee's army. It is absolutely essential, however, that the maps of the Civil War period which are included in the Rebellion Records be used in connection with any modern or accurate map, otherwise the student will acquire a false idea of the correctness and amount of information which commanders of that period had in their possession prior to ordering troops into battle.

How would it be possible to understand the many plans of Grant for the strategical envelopment of Vicksburg, without an accurate map of the Mississippi, or the strategy of the lines from Virginia through Maryland into Pennsylvania without a knowledge of the parallel mountain ranges and the roads and valleys between them, or the importance of the opening of the James River to the Federal fleet when McClellan was operating in the Peninsula? The critical student of history is no more able to do without maps than is the commander in the field.

At the present time a most profitable employment for odd moments is to follow the battle fields of the world war, and avail oneself of the opportunity to develop the power of independent criticism while history is in the making. Headline reading of the daily papers will profit you but little—in fact it will do you much harm, for quite frequently one's viewpoint lazily follows the trend of the press because we will not exert ourselves to do our own thinking. It is only by pinning out the movements of armies on the maps and studying the higher strategy involved in coordinating the far-separated lines that the mind feels its strength to think independently and to judge of the immense conceptions entertained by the brains in control.

Without a map of Western Europe we fail to understand why the Valley of the Meuse, the Vosges Mountains and the Argonne Forest made difficult the way into France through Alsace and Lorraine, or why the German flood of invasion found an easier outlet through Belgium.

It was in the Mazurian Lake region of Eastern Prussia that von Hindenberg's personality took on colossal proportions. Later in 1914 the flat, swampy country of Poland, with its poor roads and fewer railroads, proved an almost impassable barrier to Warsaw. Galicia offered an easy advance to the Russians in 1914 and '15, almost to the German frontier near Cracow, but the Carpathian mountain passes blocked the way to the plains of Hungary.

Without a careful study of the map of the Near-East States it is impossible to understand the wonderful readjustment of the war's strategy when Roumania entered the conflict. The threat of the allied army centered around Saloniki against the Orient railway; the crossing of the Transylvanian Alps by the Roumanians to extend the Russian line south of the Carpathians and recover Translyvania; the counter-blow by the German-Turko-Bulgarian force into Dobrudja—all these events prove that there has developed no other single war area wherein the possibilities of open strategy have been so fully exemplified as in the Near-East States.

When the Grand Duke initiated his move on Erzerum at the beginning of this year, what possibilities were there for combined land and naval strategy on a most unusual and remarkable scale, had there been available a Russian army of forty or fifty divisions to accomplish the reduction of Constantinople. The land operations were conducted from Tiflis, but had this invading army moved westward its strength could have been increased over ever shortening lines of communication—across the Black Sea from Theodosia, Sebastopol, Nikolaiev, and Odessa, first to Batum, then to Trebizond, Tripoli, Samsun, and Sinope.

Along the Belgian coast, where lies the secret of England's amphibious strategy which should now be in force, without a knowledge of the hydrography of the Strait of Dover and the

North Sea deceptive conclusions will be reached. Were an army put into Northern France to bend back the German line in Belgium, while an allied fleet cooperated in clearing the coast-line so as to secure a landing place at Ostend and to the eastward, then might England expect to gradually outflank the German position on the western frontier by coming down through northern Belgium, thereby compelling a readjustment of lines which would force the German right to withdraw on Louvain or he Meuse. But for the successful accomplishment of this amphibious operation, strong naval support to clear the landing places along the coast is necessary, and the hydrography of these waters shows numerous banks paralleling the shore which make it impossible for the larger warships to approach within effective bombarding range. Only a vessel of the monitor type could be used in these operations.

Critical Reading of the Daily Press

As a reading public we are inclined to adopt as our own the deas of our favorite papers and magazines, and this may be best when the views of the writer are those of the expert. But in dealing with the present war—Where are the ideas of the expert? You get very few. The public is mislead by headlines which are frequently meant to mislead, and in this connection I speak of the most conservative papers. You will find nothing more confusing than to read promiscuously, as it is impossible to learn the personality of all the writers and judge how to balance the mass of conflicting statements. It is much better to depend upon a paper like the New York *Times* which contains all of the reports emanating from Army Headquarters, many official statements indicative of national policy, and a number of excellent articles by special correspondents.

The representatives of the Associated Press in France, Germany, Greece, and Turkey have been used frequently by the Sovereign Power of the country to convey messages to the world. Such men as Washburn, who has been with the Russians since the outbreak of the war; the representative of the Associated Press who was in Turkey during the operations of the Dardanelles; Cyril Brown, now with the German Eastern Army; all these men are trying to do their work creditably, and if a reader will check up their statements by later events he will find them remarkably accurate, although due weight must be given to the touch of local bias which unconciously and necessarily enters into the articles.

The *Times* furnishes a quantity of reading matter ample for the student to form independent judgment on most of the phases of the war. If the reading is done intelligently, discriminately, with the thought ever in mind—what are the real facts which can be deduced from this article—it will soon be found that the mind is being trained to do its own thinking, and the student will begin to realize that probably some of his original ideas and deductions are of more value than those expressed by some of the self-styled military experts. You are all familiar with the daily writings and the weekly summing up contained in the *Times*, also Frank H. Simonds' excellent articles in the *Tribune*. These men do no more than any officer can do for himself each week if he follows this fascinating war game from day to day. It is not necessary to take more time than to read the brief official despatches published daily; pin out the movements of troops; study the terrain as shown on the best maps published at the Leavenworth Schools or the Army War College, and very soon it will be evident that what one has accomplished during the week is what the above named writers do themselves.

But the time spent in reading will be wasted if you are without maps, even though you be the exception and possess a most extensive knowledge of the geography and hydrography of Europe and Asia, for the mind will be assailed by a confusion of ideas that can be cleared up only by concentrating the attention upon a concrete picture of the country or the area being fought over.

CONCLUSIONS

The training which the mind receives by engaging in work of this nature pertains to the higher domain of World Strategy in its broadest sense. This includes a knowledge of national policy, finance, economics, strategy, all of which today are integral parts of Military Strategy. In the past, *Armies* fought—today, War means a *conflict of Nations*.

And as we look ahead trying to foresee the future of our country, we must realize that no matter whether war comes, or not, its shadow at least will be there. With this menace confronting us, those who control the destinies of our Army and Navy can stand with a stronger confidence, and face the future with a more determined will to overcome our condition of unpreparedness and create a fighting machine capable of conquering, if their training in peace times has included that cold analysis of historical material which develops in the soldier power to see clearly into the Fog of War.

APPENDIX "A"

The Military Records of the Civil War are contained in the publication known as the "Official Records of the Union and Confederate Armies." The voluminous character of the archives which it was necessary to examine in the course of the compilation of this publication is indicated from the fact that they embrace the records, Union and Confederate, of every company, battery, regiment, brigade, division, corps and army, as well as those of geographical military departments and divisions, and include the files of the War Department and all of its bureaus. The Union records are to a great extent complete; those of the Confederacy are in many respects deficient. The more important documents are preserved in the State, War, and Navy building and in other buildings in the City of Washington, while others, not required for daily consultation, are stored elsewhere.

The initiation of the project of collecting for publication the official records of the Civil War was taken by Congress in a joint resolution approved May 19, 1864, which directed the Secretary of War to furnish the Superintendent of Public Printing with copies of correspondence, reports, etc., which it would be proper to publish.

Col. E. D. Townsend, Assistant Adjutant General, U. S. Army, commenced the work of copying at once.

In 1865 the work of collecting the Confederate records was initiated.

Up to December 1, 1877, this work had been carried on without system under different superintendents, and at that time forty-seven volumes (thirty-seven relating to Union and ten to Confederate operations) had been compiled and put in type. No attempt had been made to collect the matter so that the records relating to particular actions and events should be assembled in consecutive order.

It being desirable that the work should have the undivided attention of a single head, Captain Robert N. Scott, Third United States Artillery, was detailed December 14, 1877 to take charge.

For several years the compilation continued along the lines already established, until seventy-nine volumes in all were printed, but after being nearly three years in charge of the work, Captain Scott recognized the necessity of a methodical arrangement of the matter so that the general reader could find in one volume a connected account of any military event, and a plan of publication was prepared, which was never departed from. This plan was as follows:

The first series will embrace the formal reports, both Union and Confederate, of the first seizures of United States property in the Southern States, and of all military operations in the field, with the correspondence, orders, and returns relating specially thereto, and, as proposed, is to be accompanied by an atlas. (111 Books.)

In this series the reports will be arranged according to the campaigns and several theaters of operations (in the chronological order of events), and the Union reports of any event will, as a rule, be immediately followed by the Confederate accounts. The correspondence, etc., not embraced in the reports proper will follow (first Union and next Confederate) in chronological order.

The second series will contain the correspondence, orders, reports, and returns, Union and Confederate, relating to prisoners of war, and (so far as the military authorities were concerned) to State or political prisoners. (8 Books.)

The third series will contain the correspondence, orders, reports, and returns of the Union authorities (embracing their correspondence with the Confederate officials) not relating specially to the subjects of the first and second series. It will set forth the annual and special reports of the Secretary of War, of the General-in-Chief, and of the Chiefs of the several staff corps and departments; the calls for troops, and the correspondence between the National and the several State authorities. (5 Books.)

The fourth series will exhibit the correspondence, reports, orders, and returns of the Confederate authorities, similar to that indicated for the Union officials, as of the third series, but excluding the correspondence between the Union and Confederate authorities given in that series. (3 Books.)

On June 19, 1882, a bill was introduced in Congress authorizing the Secretary of War to receive for publication post-bellum matter. Lieutenant-Colonel Scott pointed out the confusion and controversies to which such legislation would inevitably lead, in the following report:

> The experience of this office has demonstrated the utter unreliability of recollection of the war. I have had a Union colonel apply for permission to retract a statement never made in his report of Ball's Bluff. A general officer has complained that his report of Shiloh was garbled, but when shown his original report he acknowledged that it was correctly printed. Again, a Confederate major-general denied ever having made a report that he saw noted in our catalogue, and on inspection it was found to be in his own handwriting, and he so acknowledged. As another instance I would mention that an attempt to ascertain who commanded a certain Confederate brigade in the Gettysburg campaign has developed two claimants for the position.

The bill was not enacted, and the Department continued its previous policy of excluding post-bellum matter.

Under authority of an act passed March 2, 1889, the further preparation and publication of these records was placed in the hands of a board of three persons, acting under the Secretary of War.

The board named was:

> Major George B. Davis, Judge Advocate, U. S. Army,
> Mr. Joseph W. Kirkley, and Mr. Leslie J. Perry.

On July 1, 1895, Major George B. Davis was relieved from duty on the board by Major George W. Davis, 11th U. S. Infantry. The latter served as president of the board until June 1, 1898, when he was relieved by Colonel Fred C. Ainsworth, Chief of the Record and Pension Office.

No use was made of the preliminary and obsolete edition of seventy-nine volumes, except as printers copy in the compilation of the later and regular official publication.

The first book of the present publication was distributed in July, 1881. The last volume of the records was published in 1900; the General Index in 1901.

During the progress of the work the Department received many communications inviting attention to supposed errors or discrepancies in the published records. In some cases the alleged errors were manifestly those of the compiler, copyist, proof reader, or printer, and all these have been corrected so far as they have been discovered by the Department or brought to its attention. But in nearly every case it was found that the errors, if errors they were, that had been discovered in the published records, existed in the original papers themselves, and these the Department refrained from changing or correcting in any way. The papers were published as they existed during the war, all errors and discrepancies included, in order that the reader might have before him the exact data upon which the participants in the war based their actions.

A uniform style of composition was adopted, and this necessitated certain unimportant departures from the original records in such minor items as those of spelling, punctuation, abbreviation and capitalization, but these changes were merely typographical. As a general rule numbers under 100 were spelled, and all above ninety-nine were printed in figures. Signatures were printed as written, save that in case of obscurity arising from incompleteness of names, sufficient of the lacking names has been supplied in brackets to identify the signers. Headings were reduced to a standard, and some missing parts of headings were supplied by bracketed insertions. Paragraphing was not strictly followed as in the original documents, short paragraphs having been consolidated, wherever practicable, to economize space. "Burgh" has been uniformly printed "burg," "boro" has been printed "borough," and other similar typographical rules for uniformity of spelling were followed, but the greatest caution was invariably used to guard against any change in the language or meaning of the documents.

It will thus be seen that any error (other than typographical) that may have been made by an officer in an original official communication will appear in the printed record. The Department declined to permit corrections of these errors, as such a course would have opened up endless controversies and uselessly prolonged the period of publication. Therefore, not assuming to decide or express an opinion upon the correctness of statements made or matter contained in the several volumes, the Department strove to present the papers as they had been actually written and acted upon officially, leaving to the student and historian the task of investigating controversies and deciding disputes.

OBSERVATION OF FIRE

By First Lieutenant CECIL G. YOUNG, C. A. C., U. S. Army

The correct observation of fire of a battery is one of the most important of all the elements of the position finding service. At small ranges the battery commander can probably adjust his fire so as to get on the target. At the longer ranges, however, it will be almost impossible to correct the fire from the battery, yet at such ranges, due to the small danger-space, is where correction is needed most. The less the dispersion of a gun, the more necessary is a close correction in order to place the center of impact on the target. To separate one battery's shots from those of another, some sort of adjustable tracer should be devised that can be made to work or not, as desired, so that the correction shots for a particular battery can be picked out. In the absence of such means, the following plans might be used.

1. The batteries to fire could be directed to fire in a certain order; each shot, say, not less than ten seconds after the previous one, the batteries firing in order till the desired number of correction shots were fired. The observing station would be given the target at the same time as the batteries and also their order of firing, consequently the results as soon as seen could be sent to the proper battery.
2. If the arrangement under (1) is impossible, have the man on the battery end of observing line start a stop-watch as the gun fires. About three seconds before the time of flight is up, he calls, "Ready," and then "Splash" at the end of the time of flight. The observer on the other end of line gets the splash that comes at that instant, and calls the result to the battery. Most of the splashes should be caught this way for the proper battery as the only chance for error is in two splashes coming simultaneously from different batteries.

If correct observation of fire is not made and used, especially at the longer ranges, a battery can throw away all its shots due to inability to correct its fire.

If only a limited number of air-craft are at hand, it would also be necessary to depend upon correction from shore since air superiority will be lost due to the larger number of armed aeroplanes which would accompany the strong fleet of a well-prepared power.

Observation-of-fire stations, used as described below, would be placed in the most favorable places to give the best results in any particular field of fire and arranged so that they could be connected by telephone with any battery. There are very few coast defenses where such stations cannot be placed far enough on the flank to give good intersections with the line of fire even at long ranges. The batteries would use the station whose line of sight was nearest to the perpendicular to their line of fire. To enable a battery commander to get the proper station without delay, a chart would be made for the battery giving in the field of fire the zones of observation which belong to a particular observing station. (Fig. 1.) Just before starting to fire, the battery commander will pick out the proper station to connect with. All observing stations, especially if outside the coast defenses, will be small and hidden. The ranges and azimuths of all observing stations, or points possible for such use will be known in all the batteries. At each station would be trained observers with instruments

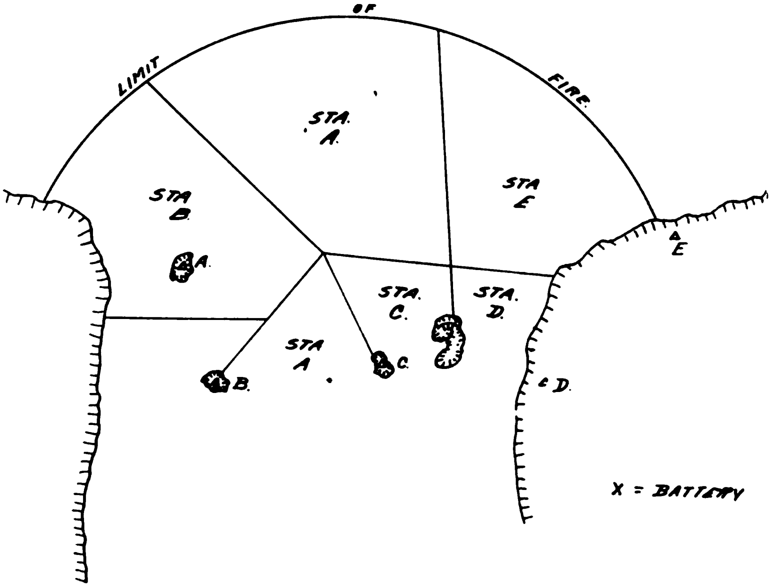


Fig. 1.

containing an angular or mils scale and having a large field of view. Temporary stations with a wire run to them would be sufficient.

Keeping the battery end of the observing line in the safest place at the battery will be a big aid to any emergency system, the only thing needed in addition to the observing line being something for getting the approximate range and the range travel in a given interval. For instance, suppose the battery commander's station and plotting room have been destroyed by a shell. If the end of the observing telephone line were placed underneath the emplacement in a magazine room with only a branch running to the battery commander, then, by means of a horizontal self-contained base, firing could be continued and corrected. In fact, probably the potential power of the battery would be greatly increased by having all the telephone lines end in a set of telephones underneath the emplacement with branches to the battery commander's station and plotting room (if the two were built together), the emplacement set to be used only when necessary. By putting the plotting room underneath the emplacement, the branch lines for that would not be necessary. A second range error device, as described below, and some sort of plotting board would be kept in this emplacement room as a reserve. Then observation of shots would be used to get on the target, according to the method to be described.

One method used in observation of fire is to obtain the range of splash and subtract the range of target at instant of splash (or point fired at). This is slow and cumbersome and very liable to error in getting the two ranges that go together, and would be especially so in time of action. It requires four azimuth readings, two for target and two for splash, and then the plotting of both sets. If the point fired at is used, still more quantities have to be taken into account. Our batteries are not well adapted to firing by salvos and to the system of spotting used by the Navy. This is due to the different powders used, the smaller number of guns, their more scattered positions, and furthermore such a method of correction is not necessary for coast defenses. If a vertical base is used in getting splashes, the ranges will not be accurate enough to use at any long range. Also if the observer is at the battery, observation of fire in actual action will be almost impossible due to smoke, discharge of one gun coming at time of splash from another, target obscuring splashes either by itself or by the smoke of its guns and interfering at the battery by the bursting of its shells in front of or on the parapet. An observing station on a flank will not have all these disadvantages and will probably last longer than one at or near the battery.

The following method for observation and correction of fire, using observing stations as described above, does not interfere with the plotting at the battery; can be quickly used at any battery; and besides, not having the disadvantages of the above method, is simple to work.

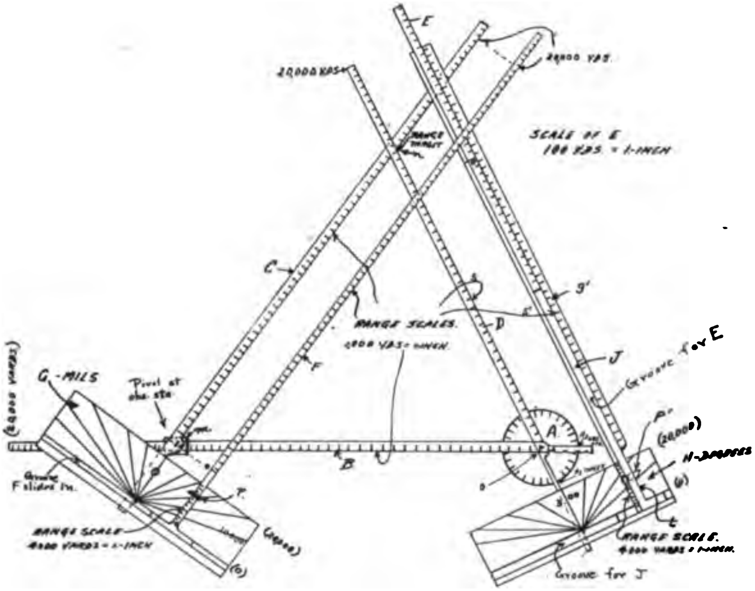


FIG. 2. 1996

A device is made as follows for getting the range errors of splashes. (Fig. 2.) *A* is an azimuth circle 6 inches in diameter, giving azimuths every 5 degrees up to 360 degrees. *B* is pivoted at the center of the azimuth circle and has a range scale of 1000 yards to the inch from the center of *A* up to the maximum range, say, 20,000 yards. The index *m* slides along *B*. Upon *m* is pivoted *C* which also has a range scale of 1000 yards to the inch. Sliding on *C* is a board *G* with a chart. On the chart are lines giving for each range the number of mils corresponding to distances at the scale of 100 yards to the inch from 0 to 20,000 yards. The vertical scale is 4000 yards to the inch. The mils of the Signal Corps field glasses each 1-6400th of a circumference, or 0.0562 degree or minutes. To make the chart *G*, get the natural tangent corresponding to multiples of the 5-mil angles and multiply by 10,000; on the horizontal 10,000-yard line lay off from the normal line, which will be at the edge of *C*, these distances at scale of 100 yards to the inch and through the points draw lines to meet the center at zero range, and divide each into 5 parts to get the lines for each mil. T-square *F* slides upon *G*. The arm *D* is prolonged also beyond azimuth circle *A* and holds deflection chart *H*. On *H* the T-square *J* slides. In *J* slides the scale *E* which is graduated from 0 at center to 1000 each way at a scale of 100 yards to the inch to go with scales *G* and *H*. On *H* radiating lines give for each range the distance corresponding to a given angular deflection at the battery at a scale of 100 yards to the inch. *H* is made in same manner as *G:* at the 10,000 horizontal line the natural tangents corresponding to each 0.25 degree are laid off at a scale of 100 yards to the inch with 10,000 as one side of triangle, subdividing to 0.05 degree; vertical scale of *H* is 4000 yards to the inch. The lines giving angles run from 0 through 3.00 (normal) to 6.00 to correspond to deflection instruments usually used at the battery. On *D* and *J* are scales of ranges *s* and *s′* starting from center of *A* to scale of 1000 yards to the inch. T-square *F* also has a similar scale. For ranges under 4000, divide all figures by 5 and put the resulting numbers under the large ranges in red ink; this applies to all scales except the mils and deflection numbers on *G* and *H*—these remain the same.

Method of use is as follows: *B* is set at azimuth of observing station from battery, *m* at its range. *D* is put at the approximate azimuth of target at time of splash. *C* is put at the approximate range of target read on scale *s*. Scale *E* is slid in *J* so that its zero is at intersection of *D* and *C*. *F* is then moved on *G* till it intersects the mils over or short called from the observing station, taking it at the range on *G* that is intersected on *C* at *n*. On *E* is the over or short in yards, if deflection was zero or nearly so. If deflection error was large, move T-square *J*, whose edge *t* was at normal or at edge of *D*, and on the center 3.00 line of *H*, till the edge *t* intersects the deflection read at battery, taking it at the range on *H* that is intersected on *D* at *n*. Intersection of *F* with *E* now gives over or short corrected for deflection. If a point allowing for danger-space beyond target has been fired at, move *E* up till the danger-space correction used is opposite *n*. This gives the over or short corrected for danger-space.

It takes longer to describe this device than to work it. To get the shortest time of operation, let one man keep *D* and *F* constantly at their proper positions with the zero of *E* or danger-space correction at the proper point. The second man will have one hand on T-square *F*, the other on T-square *J*. When the mils over or short are called to him from the observing station, he slides *F* to the proper point, then *J* to the deflection error if large enough to affect the result, and reads the over or short on *E*. To aid in getting the T-squares at the proper points, there are small indices which slide up and down on the T-squares, *P* and *P'*; these are set at the proper ranges on *F* and *J* read from the scales, and the T-square is then slid till these indices meet the mils or deflection read.

The time necessary is about as follows: from instant of splash till mils are telephoned in, about 4 seconds, telephone to come directly to operator of device; then about 4 or 5 seconds to work the device; total, about 10 seconds. Leaving the deflection correction out it gives a method a little slower than spotting for rapid-fire batteries, without the possible error of spotting. Every shot could be recorded, if desired.

This device can furthermore be immediately changed for use with any observing station. With an observing instrument of high enough magnifying power, it will give the over or short to 10 yards. For ranges from the observing station of 10,000 yards and under, the Signal Corps glasses, type E-E, 6-power, will do; they contain a scale of mils, reading from zero 30 mils each way. If this scheme were to be generally used, the graduation should be run to the limit of field each way or about 60 mils. An over or short can be judged to about one mil with these glasses, or to about one thousandth of the range from the observing station. Hence for ranges over 10,000 yards from the observing station a higher magnifying power instrument should be used to read to 10 yards, the field of view not being of necessity so large. An instrument like the Warner and Swasey Instrument Model 1910, with 15-power eyepiece will give splashes to 0.01 degree, which is accurate enough at any range. If it was difficult to get all splashes and target at the same time, which would be the trouble at close ranges, especially, two instruments could be used, one taking all splashes short of the target, keeping target at extreme edge of field of view, and the other taking all splashes over. If splashes are caught in degrees and hundredths, they can be turned by a table into mils or the scales on device can be made for 0.01 degree instead of mils.

It seems as if this method of getting splashes would be more accurate for target practice records than our present method of using a range-rake on towing boat, especially in rough weather. The only error in using this device is in assuming that the lines of sight from the observing station to the target and the splash are parallel; except for a very close range and a very large range error of splash, this is practically so.

The following might be a method of incorporating this scheme of observation of fire in the system of fire control:

Target assigned to battery. Battery connects with observing station and designates the target as it is assigned to different units of the battery; as soon as the observer identifies the target, he will telephone "On Target"; when battery is about to fire, "Ready for_ _ _ _ _Correction Shots" is telephoned from the battery and the observer will keep constantly on the target until those shots are fired, calling the observed mils over or short of each shot to the operator of the device at the battery. Deflection errors are called to the operator after the overs or shorts have been telephoned in.

If it is desired to introduce a correction through the plotting room, the following plan can be used:

On scale *E* of the device, make 1000 a normal number for zero—then scale *E* will read from 0 at bottom to 2000 at top through 1000 which represents zero. The range errors of splashes will come from *E* as reference numbers, avoiding the use of plus and minus. Add all numbers and divide by the number of shots, and at the range correction board set the ruler index at number obtained. Clamp M.V. index and move till scale under index reads 11,000; M.V. index is now at proper setting to use for rest of shots, if correction is to be thrown into M.V. An example in tabular form is given at top of next page.

Set ruler index at 11,100 and move as described above to 11,000. The use of this method would be similar even if corrections were made on each shot using whole for first, one-half correction for second, etc.

If it were not possible to connect some observing stations by telephone to the batteries, some method of signaling could be used. And if stations cannot be seen, small wireless outfits might be supplied.

Shot No.	Over or Short	
	Reference No.	Actual
1	1200	+200
2	900	−100
3	1350	+350
4	950	− 50
	4400	

(4400 divided by 4 = 1100.) (C.1. plus 100.)

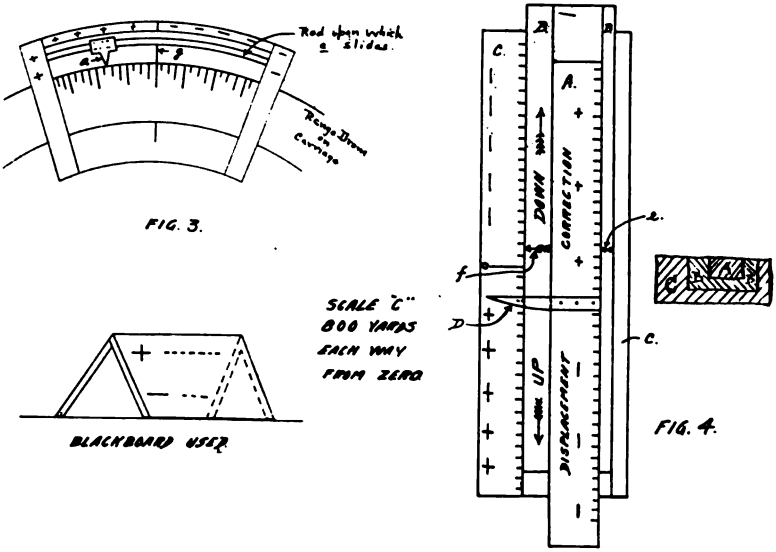
The above method of observation of fire can be made as accurate as the remainder of the position finding service, and can be used for rapid-fire guns, major-caliber guns, and mortars. With a small observing interval for plotting, it will be practicable to consider that the actual target was where it was expected to be. During an actual action this would be the only practical assumption, as then there is no time for any analysis to eliminate all possible errors of personnel. By taking several shots, the effect of any such errors will tend to balance or decrease. It will have to be assumed that the drill beforehand has been sufficient to eliminate most personnel errors, learning them from analysis of such drills.

METHOD OF CORRECTION OF FIRE, USING THE ABOVE MEANS FOR OBSERVATION OF FIRE FOR MAJOR-CALIBER DIRECT-FIRE GUNS

It seems to have been shown that at different ranges, even if the range correction conditions have not changed apparently, a battery although on the target at one range will not necessarily be on at some other range. This being so there is no particular object in making corrections in M.V. to get on the target, but make them directly for each string, using all data known about M.V. to start firing and then making corrections in that particular string directly. To make the correct range setting of the first three or four shots more certain, they could be fired on the bell with the actual range called from the plotting room or fire all shots as described below. The following method of applying corrections is rapid and as accurate during any particular string or series as applying correction through the plotting room.

At each gun on the fixed range-drum index is fastened a movable index pointer, *a* (Fig. 3) which can be set any given distance from the fixed index mark *g*.

At each end of the battery commander's walk or for each gun there stands a man with the ruler shown in Fig. 4. Arrangement for a two-gun battery is shown in Fig. 5. On the emplacement of each gun the displacement numbers are painted large enough for the man at that gun on B.C. walk to see, using the number under the breech. Each man has also a small triangular blackboard and chalk.



FIGS. 3 AND 4. 1996

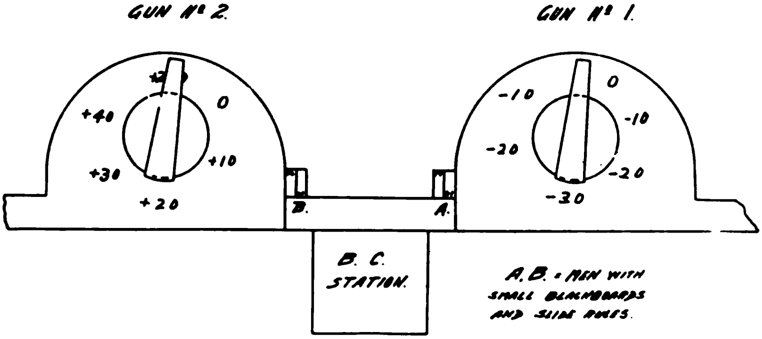


FIG. 5. 1997

The ruler is used as follows: *A* slides in *B* and has a displacement correction scale. *B* slides in *C*. The displacement correction, as read on emplacement opposite breech of gun, is set opposite index *e* by sliding *A* in *B*. The battery commander corrects first shot which falls, say 100 yards, beyond by calling to this man "Down 100." *B* is then slid in *C* till index *f* has moved in the down direction the number of yards called. On scale *C* under index *D* the resultant number read is chalked on the blackboard. As soon as the man has marked the resultant number on the side of blackboard towards the gun, he also marks it on the side towards the B.C. station. Hence the battery commander can check it. Example: if corrections had already been given such that the previous reading on the blackboard was −220 and "Up 100" was given, new reading should be −120. Further corrections from shots are introduced by sliding the ruler *B* up or down the number of yards called. A record can be kept by the operator of the ruler as follows for each gun:

Gun No. 2

Shot	1	2	3	4	5
Displacement	+20	+20	+10	+10	+10
Correction	--	--	--	--	--
Range	Up	Down	Up	0	0
Correction	100	30	20	--	--
Resultant	--	--	--	--	--
Correction	+120	+90	+100	+100	+100

Gun No. 1

Shot	1	2	3	4	5
Displacement	−30	−30	−30	−20	−20
Correction	--	--	--	--	--
Range	Up	Down	Up	0	0
Correction	150	20	20	--	--
Resultant	--	--	--	--	--
Correction	+120	+100	+120	+130	+130

At the gun, the gun commander moves the index pointer *a* from the fixed index *g* + or − the number of yards chalked on the small blackboard at that time, the + and − direction being marked on the fixed range-drum index and the range setter holding the range drum such that some even 100-yard mark is at *g*. The slide that holds the movable index *a* should be made long enough each way to allow *a* to be moved the greatest correction liable to occur. If this scheme were to be regularly employed, it would probably be necessary to use some different sort of range-drum index-frame, especially in case of carriages like the latest 14-inch disappearing. The range setter makes no range corrections whatever for displacement, but sets range given him at pointer *a*. On a bell for instance, the range as actually called from the plotting room would be set at pointer *a*. If there is a mechanical transmission device at the battery, the gun commander can check the range set by looking at the range-drum reading and the mechanical transmission reading—they should be the same.

In making range corrections, there will not be time after instant of splash to apply the correction for the next gun of the battery if guns are firing at their most rapid rate; there is time, however, between shots from the same gun. Hence, except for the first three or four shots for which time might be allowed to get the corrections in on all guns, correct thereafter each gun on its own shots. There would be other advantages from doing this from the beginning: a mistake made at a gun would affect that gun alone; if guns did not shoot together, they still would be brought on the target. The above records were made on the assumption that the guns were corrected separately. If it is known that the two guns shoot together, the average of the final corrections less the displacement corrections can be sent down to the plotting room to get a new M.V. to use, if there is time before another string. From the above two records, the data would be: No. 1 gun, +130−(−20) is +150 actual correction applied to get center of impact on target. No. 2 gun, +100−(+10) is +90. 90 + 150 is 240, divided by 2 = 120, the number of yards the center of impact would have been short of target if no corrections had been made. A M.V. for 120 yards less range is obtained.

There are some batteries which have not sufficient calibration data. By the above records the guns can be calibrated. Either gun can be taken as the base, say No. 1 gun. Make 150 yards correction for M.V. in plotting room. As No. 2 gun required only 90 yards correction to bring it on the target, as against 150 for No. 1, No. 2 shoots 60 yards beyond No. 1. On No. 2 emplacement chalk a new set of displacement correction numbers which are the old ones minus 60 yards. Using these and the plotting room correction for M.V. for 150 yards, the guns should be shooting together and on the target. The whole process would take little time.

The battery commander, or whoever makes the range corrections, could keep a record as follows:

	Gun No. 1						Gun No. 2					
Shot......	1	2	3	4	5	6	1	2	3	4	5	6
Correction	1	½	⅓	¼	⅕	⅙	1	½	⅓	¼	⅕	⅙

As he made the corrections, he would check off the fraction of correction he made and thus would know that the next shot for that gun would have the next fraction correction applied to its range error.

The above method is then a rapid method for correction of fire for major-caliber D.F. guns which at the same time can be checked closely by the battery commander. It, or some other method of correction which does not go through the plotting room, is the only possible method that can be used during firing with the time-range board as ranges coming out with corrections would make it almost impossible to get the proper ranges from the time-range board to set on the range drum. This would be especially so with a fast target as the time-range curve would have such a high angle of slope and run off the time-range board so frequently. Firing at a rapid rate, corrections made in plotting room would not get out in time to affect the next shots from both guns. In time of action it would be practically impossible to pick out the shots which already had a correction applied from those which were fired before corrections had reached them, thus making unreliable the range errors of shots for correction of fire. By using the above method of correction, the time-range curve is not interfered with and it is known exactly to what shots correction has been applied.

System of Plotting and Range Setting to Go with above Method of Correction of Fire

There are two methods of tracking a target. (1) One which we are using at present is to make the plotter judge from the track where the set-forward point will be, and then from this estimated point get the data for the guns. This necessitates an observing interval long enough to allow him to do this, and for range corrections to be made on that range.

In actual practice this does not work very well as the observing interval is too long. With a high speed target and irregular course, the error would probably be sufficient to prevent any hits except accidental shots. (2) In the second method all corrections are made on the gun arm by means of the correction box, and the plotter calls out the range as read on the gun arm. With this method a very short observing interval can be used and the target followed closely, thus giving more accurate results than the first method, especially if the target is pursuing a sinuous course.

At one of our forts the following scheme of plotting has been in use with excellent results: The interval is 15 seconds for major-caliber guns. The corrected range gets to the guns about 7 seconds after the bell for the next bell. The range travel, during the observing interval plus time of flight, is found from a series of curves on the range-correction board giving at different ranges the travel during time of flight plus travel during the observing interval for different travels; 300 is the normal of these curves to correspond to the travel scale used on the gun arm. An additional index is put on for these curves and correction from them included with the other range corrections. 2000 is used as a normal on lower scale as with the old ruler and the number to set as correction on gun arm is read on the upper scale.

To make corrections on the actual range at the range-correction board, a sliding scale is put on the side of the range-correction chart. This scale is similar to the scale on the gun-arm correction box. 2000 of this scale is put at the range called by the plotter and the range correction ruler is put at the number set on the gun-arm correction box, thus putting the ruler at the actual range of the target. With this method of plotting and the short observing interval obtainable, the following method of range setting might be used. It would reduce the chances of error in range laying and thus make the above method of correction on the actual fall of shots yet more reliable.

Each type of gun takes a certain average time between firing of shots, depending also on the training of the gun crews. Having determined this time, make the observing interval some even fraction of it, adding enough seconds to allow for any minor delays. Then always fire on the bell, and use the actual range as it is called from plotting room, setting it opposite the movable pointer as above used. The gun pointers can be trained to get the gun on the target at the bell. Range errors are more important than pointing errors at long ranges and this method insures a correct range setting, while the gun pointer, who can see the target constantly, will with practice, judging the travel, have no difficulty in getting on the target at the given instant. With our present method, the range setting is supposed to correspond to the time it is judged the gun pointer will fire. If the time is judged wrong, there is no way of correcting the range in time as there is no guide that can be quickly referred to. The gun pointer, however, has the actual target before him all the time as a guiding point. With a target of high speed and with a large range travel, this method would be especially effective. If it is desired to correct the fire of guns separately, fire them on different observing intervals. If it is known that they shoot together, they could be fired in salvos and correction made on the average of the splashes.

The following is an example of the above method: Presume that it has been found by trial that 40 seconds is the average time between shots from a gun; add, say, 10 seconds for a margin and call 50 seconds the firing interval. Make the observing interval the least possible which using the above method of plotting would be 12½ seconds, or making 4 observing intervals to a firing interval. This would follow the target closely. Assuming a time of flight of about 15 seconds, this would leave about 35 seconds to get the correction in for the next shot from that gun which would be time enough.

To prevent any important error in the plotting room passing unnoticed and hence affecting the firing and its observation results, a small board on the principle of the time-range board could be operated, the board to be large enough to take in the entire track of a target without change. The battery commander would then know of any error in plotting and would handle his observation of fire results accordingly.

The advantages of this method of range setting are that it follows the target closely, there is a double check on the range every time as the mechanical transmission device and range-drum setting should be the same, using the movable index. It gives a regular time for firing which would have less chances of error than firing at irregular times. It gives the advantages of creeping without the faults, due to the small observing interval. The little time lost is nothing to the increased chances of accuracy in firing.

CROSS-SECTION PAPER TIME-RANGE CHARTS FOR USE IN PLOTTING ROOM OR AT GUNS

By Captain HUGH B. McELGIN, C. A. C., U. S. Army

Construction

Attach sheets of cross-section paper (10 to the inch) 20 inches wide and 6 feet long to a suitable board, one on each side of the board.

These are the time-range charts. On them the time lines are horizontal and the range lines vertical. The range scale is 100 yards to the inch; time scale, 30 seconds to the inch. The time lines should be drawn in a contrasting shade of ink, i.e., black on red lined paper, or black or red on green lined. The 30-second lines should be heavy and continuous, the 5-, 10-, 15-, 20-, 25-second ones lighter and broken. Some may prefer to use only 10- and 20-second interpolated lines.

Range lines should be permanently marked with the proper range numbers at their intersection with 30-second lines. On one chart the ranges marked should be from 1000 to 8200 yards, on the other from 6000 to 13,200 yards.

The device for determining the range at which the piece is to be laid may be one of the following: (a) a rectangular piece of window glass or thick transparent celluloid 6 inches to 8 inches long and 2 inches wide on which are drawn, or cut, lines parallel to the longer sides and to each other and separated from each other by a distance equal to the tripping interval, to the scale of the chart; or (b) a frame consisting of a flat strip of wood, about 8 inches long, 1 inch wide, and ¼ to ½ inch thick, at each end of which is attached a perpendicular strip 4 inches to 6 inches long with threads or wires stretched taut between and fastened to the uprights, parallel to each other and the lower member, and a distance apart equal to the tripping interval to the scale of the chart.

Operation

The time curve is drawn as prescribed by Par. 400, *Coast Artillery Drill Regulations, 1914*. It may be started from any intersection of a 30-second line and the proper range line and toward the top or bottom of the board.

When it reaches the top or bottom it is not necessary to transfer it to the other edge, but at any convenient intersection of a range and 30-second line it may be turned and produced toward the other edge.

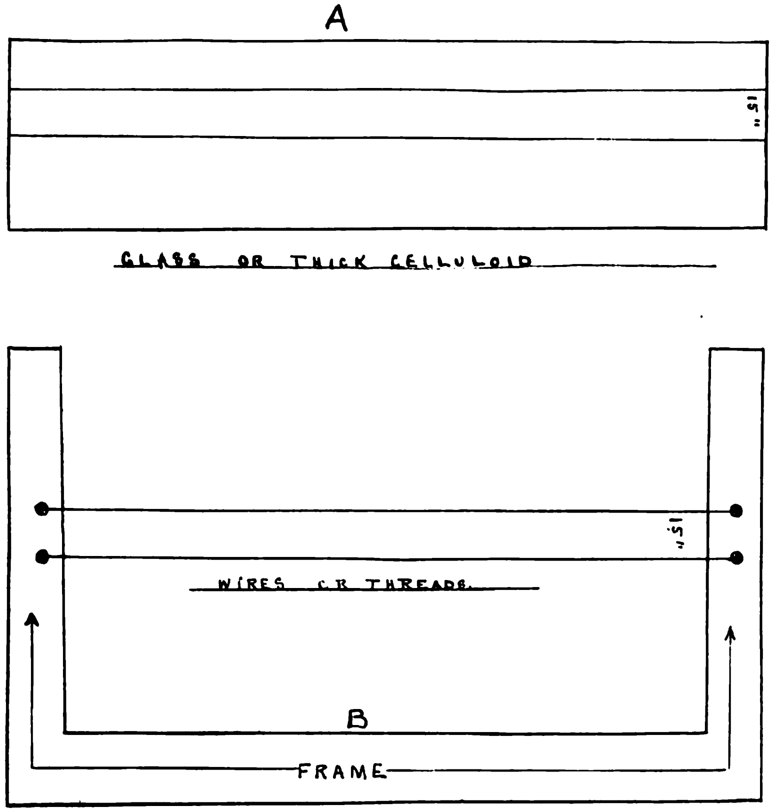


FIG. 1. 1998

The curve should be drawn with a soft lead pencil, and may be erased with soap eraser (procurable from any stationer) when no longer required.

When the command "Trip" is received, the range at which the gun is to be laid may quickly be ascertained by placing one of the lines of the device used on the line corresponding to the time at which the command was received and reading the range at the intersection of the curve and the other line.

A straight-edge of the device may be used as a ruler to assist in drawing the curve, or the curve may be drawn free hand.

When the tripping interval is short, the range at which the piece is to be laid may be determined by inspection.

Several devices suitably arranged and marked to prevent error will be required for barbette batteries, where the time of laying varies with the range.

AN AUTOMOBILE TARGET AND A DEVICE FOR REMOVING A DUMMY PROJECTILE STUCK IN A MORTAR

By First Lieutenant LEIGH F. J. ZERBEE, (C. A. C.) S. C., U. S. Army

An Automobile Target

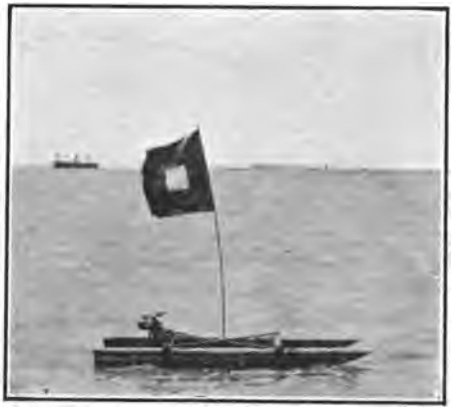


Fig. 1. 1999

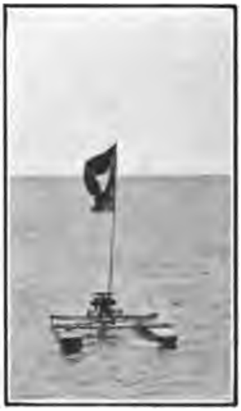


Fig. 2. 2000

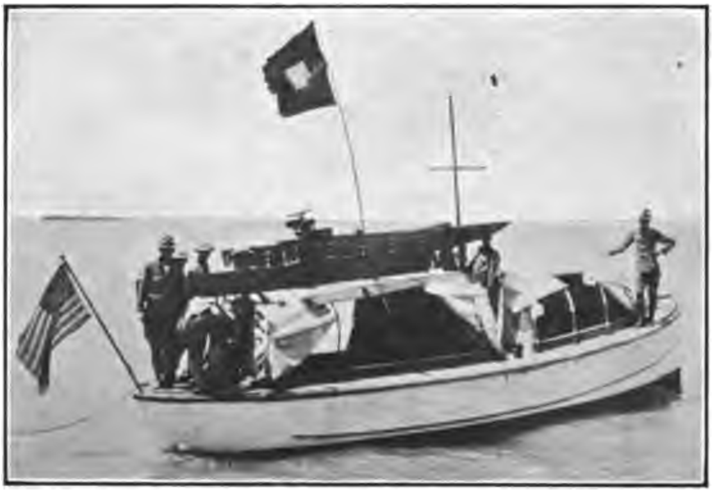


Fig. 3. 2001

In reference to the article entitled "An Automobile Target for Land Defense Guns," by Captain Le Roy Bartlett, C. A. C., U. S. Army, in the January-February, 1917, issue of the JOURNAL U. S. ARTILLERY, Figs. 1, 2, and 3 will probably prove of interest to the Corps. Figs. 1 and 2 show the automobile target underway, and Fig. 3 shows the target on top of launch.

The target shown in the figures was made and operated in the Gulf of Mexico in 1915. It made a speed of eight miles per hour and after a run of three quarters of an hour it was only one point off the course originally set.

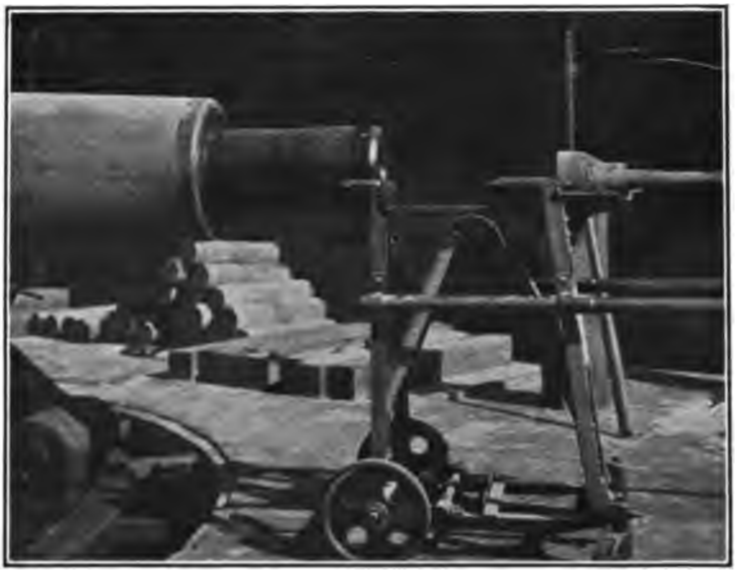


FIG. 4. 3062

A DEVICE FOR REMOVING A DUMMY PROJECTILE STUCK IN A MORTAR

Fig. 4 shows a unique method of removing projectiles that have been stuck in the mortars at drill.

After all other methods have failed, remove the rotating band of a dummy projectile. Place the projectile on a truck and, with the mortar in the horizontal position, gently ram it down the muzzle and against the projectile to be removed—it will be loosened at the first blow. Withdraw the projectile from the muzzle with the hand extractor, open breech and withdraw the charge as usual.

A BATTERY COMMANDER'S STATION

By Captain JACOB FRANK, C. A. C., U. S. Army

In prior practices at the battery referred to, a 3-inch (15-pdr.) three-gun battery, it was found impracticable to properly control the fire from a position on the flank and hence it was decided to construct a battery commander's station in rear of the center and as shown in the figures.[1]

The material, furnished by the Engineer Department and procured for about twenty-five dollars, consisted of:

4 pieces	8 inches by	8 inches by	12 feet
4 "	8 "	" 8 "	" 10 "
1 piece	8 "	" 8 "	" 16 " (instrument pier)
20 pieces	2 "	" 10 "	" 10 "
1 piece	108 "	" 30 " of beaver board	

20 pounds of 20d. nails.

The work was done by the two Company Mechanics who completed the station in eight days.

Operation

Ranges from the plotting room are received by the telephone man and chalked up by him on small board at right of station (see Fig. 2). The man operating the range board posts the range, making such corrections as have been ordered by the battery commander. Deflections are received over the same telephone and posted by the range board operator on the deflection board. Corrections, as noted by the spotters, are transmitted to the battery commander by megaphone, or, where impracticable, by telephone.

Fig. 3 shows the telephone with small blackboard to write range and deflection on as received from the plotting room. The deflection board, shown with 3.25 written on it, revolves and, when a new deflection is displayed to the guns, the old

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[1] Other photographs and a complete set of constructional working drawings were submitted with this article. The drawings, however, are too large to stand the reduction necessary for publication in the Journal.—*Editor.*

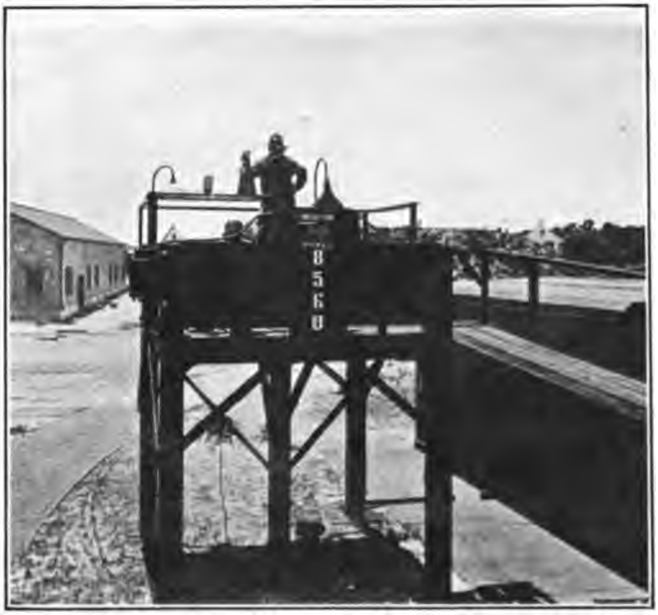

FIG. 1.
FRONT VIEW (IN USE)

3003

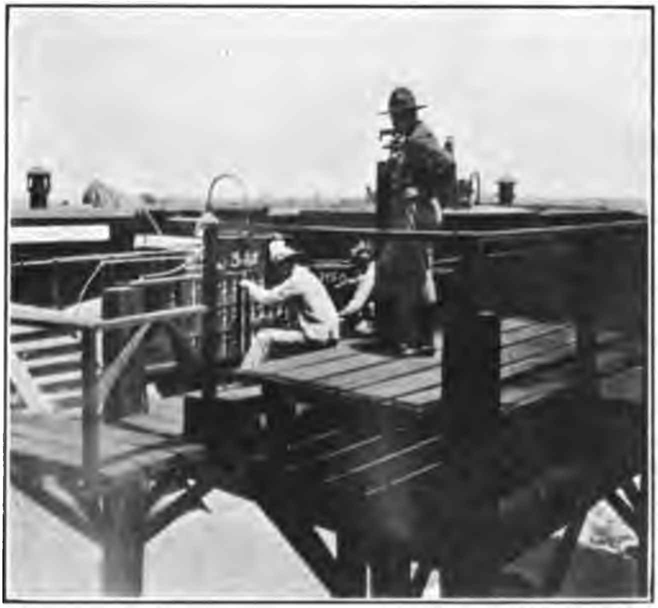

FIG. 2.
REAR VIEW (IN USE)

3004

deflection is erased. The three slides are operated by pegs shown, the zero being stationary. Fig. 2 shows the board in operation, under direct view of the battery commander at the azimuth or deflection instrument. Fig. 1 shows the range and deflection as seen from the guns.

ADVANTAGES

a. All elements of the battery, such as guns, spotting station, magazines, range and deflection recording devices, and the personnel pertaining thereto, are in plain view of the battery commander at all times. The battery commander also has a good view of the field of fire. Range and deflection are easily seen from all guns.

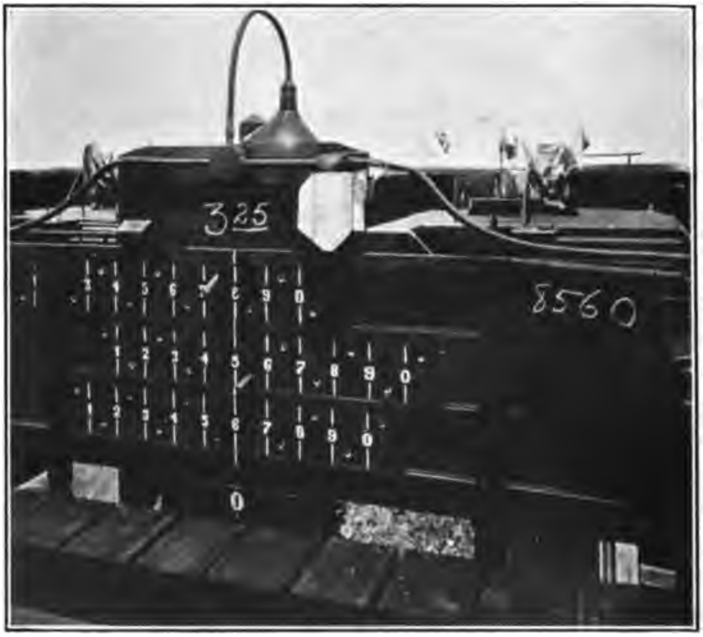

FIG. 3. 2005
REAR VIEW (IN DETAIL)

b. No confusion incident to calling out ranges and deflection, this data being taken direct from the board by the gun pointers and range setters.

c. The system of lighting at the station gives excellent illumination for range and deflection data. The shades used on these lights concentrate the light direct on the data, and there are no rays of light that are deflected to the battery commander's platform or to the guns.

d. The battery commander, from his position, can very easily check the ranges and deflections that are posted on the board.

e. No additional personnel is required to man this station.

f. The construction is simple, rigid, and inexpensive. The concussion at the guns do not disturb the data on the board.

(NOTE.—This construction places the elements of fire control of the battery above and in rear of the center—*the most vulnerable place in every target.*

By placing the apparatus, with the exception of the observing instrument, close to the ground, the detail would work in greater security and therefore with greater efficiency—*Editor.*)

A CIRCULAR LOGARITHMIC PREDICTER

By Second Lieutenant C. M. FROST, C. A. C., Cal. N. G.

The instrument here shown was designed by the writer in April, 1914, and has been in use continuously since that time, both in armory drill and in service practice.

It may be made of wood, such as mahogany or maple, or of heavy paper card stock, with brass center, index, and pointer.

The device consists of a rectilinear scale reading right and left from a central zero, one inch equals 300 yards, least reading is 10 yds. In conjunction with this is a circular slide rule of 180° base, i.e., 10 = 180°, and 100 = 360°.

A range scale is erected for the particular model of gun and type of projectile which it is desired to serve. That shown in the illustration is for the 10-inch B.L.Rifle, Model of 1895, with a 604 pound projectile, and a muzzle velocity of 2250 feet per second.

In computing the range scale, 200-yard intervals are sufficient, and interpolations may be set off very accurately with the index pointer.

In the operation of "predicting," by whatever means, the plotter measures the last observed travel and multiples it by a "prediction factor" determined by the range. This factor may be represented by the mixed number $1\frac{t}{30}$, in which t = time of flight for the given range(expressed in seconds).

As an example: range, 12,000 yards; gun and projectile mentioned above. Prediction factor equals:

$$1\frac{24.22}{30} = 1.808$$

Log 1.808 = .257198 which, multiplied by 180 (the angular base of the slide rule) gives 46°.30, the angular value of 1.808 measured from the index or origin of the rule. The other range values are similarly computed and laid off. An auxiliary range scale may also be erected for the sub-caliber time-of-flight table.

In operation the inner disc is moved until the index points to the range of last set-forward point. As soon as the arms are cleared the plotter lays the scale along the track of the target with the zero at last plotted point, notes the distance to previous plotted point, and, without moving the instrument, finds this number on the inner scale of the slide rule, setting it off with the revolving pointer. On the outer scale, coincident with this reading, he finds the distance to set-

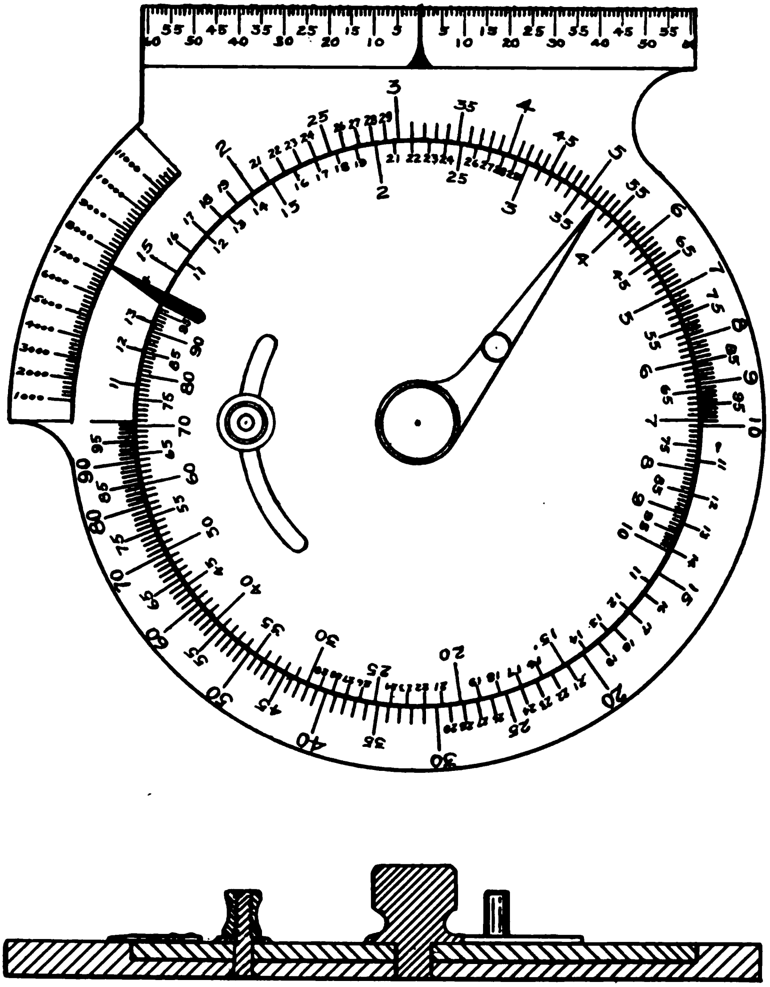

FIG. 1.

forward point and sets it off on the opposite side of the rectilinear scale. He then removes the predicter and swings up the gun arm for the range reading.

In the illustration the range index is set at 7400 yards; the pointer is set as for a travel of 370 yards; and a prediction of 520 yards is indicated. Exact computation gives a result of 522.07 yards.

The following table of angular values of numbers from 1 to 100, computed for slide rules of 180° base, may possibly be of value to anyone wishing to construct a similar instrument.

No.	Angle	No.	Angle	No.	Angle	No.	Angle
1	0.00	26	254.69	51	307.36	76	338.55
2	54.18	27	257.64	52	308.88	77	339.57
3	85.88	28	260.49	53	310.37	78	340.58
4	108.37	29	263.23	54	311.83	79	341.57
5	125.81	30	265.88	55	313.26	80	342.56
6	140.07	31	268.45	56	314.27	81	343.53
7	152.12	32	270.92	57	316.05	82	344.48
8	162.56	33	273.33	58	317.42	83	345.44
9	171.76	34	275.67	59	318.75	84	346.37
10	180.00	35	277.93	60	320.07	85	347.29
11	187.45	36	280.13	61	321.36	86	348.21
12	194.35	37	282.28	62	322.63	87	349.11
13	200.51	38	284.36	63	323.88	88	350.01
14	206.30	39	286.40	64	325.11	89	350.89
15	211.70	40	288.37	65	326.32	90	351.76
16	216.74	41	290.30	66	327.52	91	352.63
17	221.48	42	292.18	67	328.69	92	353.48
18	225.95	43	294.03	68	329.85	93	354.33
19	230.17	44	295.83	69	330.99	94	355.16
20	234.18	45	297.57	70	332.12	95	355.99
21	238.00	46	299.30	71	333.23	96	356.81
22	241.64	47	300.98	72	334.21	97	357.62
23	245.11	48	302.61	73	335.39	98	358.42
24	248.44	49	304.24	74	336.46	99	359.21
25	251.63	50	305.81	75	337.52	100	360.00

PROFESSIONAL NOTES

AERIAL NAVIGATION OVER WATER

(Paper to be presented at Annual Meeting, Society of Automobile Engineers. Subject to revision.)

By ELMER A. SPERRY,[1] Member of the Society

ABSTRACT

The author calls attention to the unreliability of the magnetic compass when used for aerial navigation and to the possible development of the gyroscopic compass for this purpose. He then explains how the drift of an airplane in flight makes it difficult to follow with accuracy a given course devoid of landmarks, unless an accurate drift indicator using the principle of the stroboscope is available.

The development of such an instrument is then described, as are also means for synchronizing it with the compass. The use of the automatic synchronized instrument in flight over land is outlined, and its application to flight over water is described in considerable detail. Rules for aerial navigation over water, observation as to movement of wave crest and determination of wind velocity and direction are considered in their relation to the use of the instrument.

The author, because of the development and practical application of his gyro-compass, has been brought to consider, more or less broadly, the whole science of navigation. For many decades past, this science has been one of high exactitude, limited only by the accuracy of the instruments used in obtaining its ground work or in giving it its base lines.

It has long been known that the magnetic compass is unreliable; as ships represent greater and greater masses of steel, this inaccuracy has become more and more aggravated. Methods of checking its accuracy have been diligently sought for and made as nearly perfect as possible. These, however, depend upon observations and fail usually just at the time they are most needed; namely, when observations of the heavenly bodies are impossible. All this emphasizes strongly the desirability of an instrument of precision that will function as a compass. The adaptation of the gyroscope is found to fulfill this satisfactorily.

LIMITATIONS OF MAGNETIC COMPASS

Among the difficulties met in using the magnetic compass in the air is that known as the heeling error. When a magnetic compass is used on airplanes, and the machine is even mildly "banked," and persists in such a position for an appreciable period, the heeling error is found to be of such magnitude as to render the compass useless. In some instances it will amount to 360 deg., or around the entire circle, giving no clue whatever to the aviator as to the true azimuth, or where to stop on the turn and straighten out into the tangent. Thus the compass fails him utterly at just the critical time when it is most needed. After the tangent is persisted in for a sufficiently long time for the compass to settle, then and then only does it again become useful.

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[1] President, Sperry Gyroscope Company.

Moreover, the lag or tardiness of action of the magnetic compass is a serious drawback. The magnetic compass, to be reliable, we find, must be of the so-called liquid type; upon spiralling and making two or three turns the liquid is found to take up the swiveling motion, carrying the card with it round and round, and becoming a serious disturbing factor for some time after the airplane straightens out on the tangent. This is not meant to imply that the magnetic compass is not an extremely useful instrument upon aircraft, but for best results it should be understood by the aviator and not relied upon when conditions are such that it is impossible for it to function.

This condition has become so aggravating that the United States Navy is ordering a gyroscopic compass to be employed on airplanes. Much interest centers in the results that it will be possible to achieve by substituting this instrument for the magnetic compass under practical service conditions in the air. By extreme refinement in execution and design it is expected by the Navy Department that the weight of this instrument will be reduced to 20 or 30 lb.

When one is navigating the air and holding an absolutely true course, that is, with the lubber line of the compass precisely upon the desired heading in azimuth, the direction of flight coincides with this heading, under the condition of absence of movement of the medium, namely the atmosphere, through which the flight takes place. At first thought, one would think that at the moment the medium itself was moving, and especially when this movement was normal or at a small angle to the direction of flight, the compass would instantly indicate the resulting deviation from the true course. This conception, however, is not correct.

An aviator can hold his course true to the compass and still be following a course having a wide angle of deviation from the course in which he thinks he is flying. For instance, Carlstrom, in his noteworthy flight from Chicago to New York (equipped with instruments described later), found he was drifting 17½ deg., when flying over Cleveland; his apparent course had to be changed to this extent to neutralize drift and to maintain the true direction along the south shore of Lake Erie. This angle was given him by his drift set, which, although not indispensable, he used throughout his flight. Carlstrom, however, had the shore line and general land marks to aid in his guidance. The case would have been different had he been flying at sea out of sight of land, where no land marks could possibly be seen. Then certain aids to navigation are indispensable, and it it the province of this paper to discuss briefly some general aspects of these instruments and their uses, no effort being made to present a mathematical or an exhaustive treatise on the subject.

DETERMINATION OF DRIFT

Let us assume an airplane maintaining a compass course due north with the lubber line of the compass maintained at zero on the card, and for the moment the compass properly functions without variation or deviation. In still air the course of this machine over the surface of the earth will be north. But suppose, wholly without the knowledge of the aviator, the medium in which he is flying is itself in motion toward the east with a velocity equal to that of the aircraft. It is quite evident that, although he holds his course with exactitude, the craft itself is passing over the surface of the earth on a diagonal, that is, his actual course is northeast; the easterly component of his course depends upon the eastward velocity of the medium. Again, if this velocity be half of that of the aircraft, then his real course is 22½ deg., or "north-northeast." The question arises: how is the pilot to obtain this knowledge, or knowledge that he is drifting at all, so as to make the necessary correction of course in the absence of landmarks or other indications to guide him?

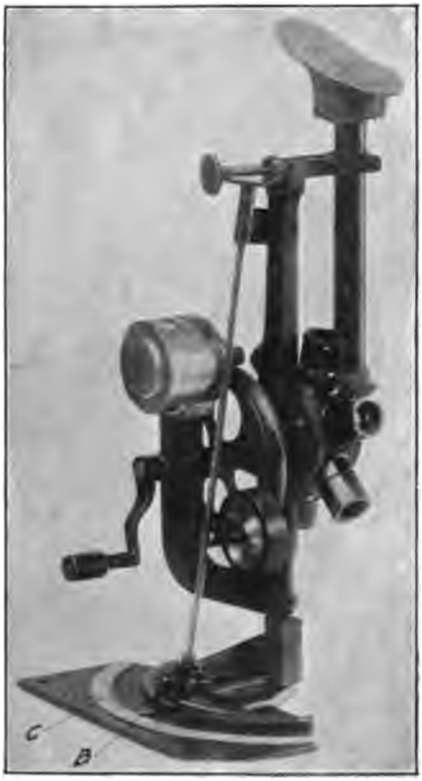


FIG. 1. 2007
EARLY FORM OF DRIFT INDICATOR

A device, worked out by the author some time ago to give pilots this knowledge, has now come into general use, and is found to perform its function satisfactorily. Fig. 1 shows an earlier form of this device, in which a series of moving observing tubes acted as a stroboscope. By the backward movement of these tubes a point upon the earth's surface could be made to appear as though it stood still; the backwardly moving point of persistence of vision being exactly equal to the forward advance of the machine. Knowing the angular velocity of these vision tubes, or simple telescopes, and the altitude, the actual speed over the earth's surface was at once obtained. When compared with the anemometer speed, that is, the real speed of flight through the atmosphere, a clew was at once available as to the actual movements of the atmosphere itself.

This instrument was then carried a step further. The telescopes were furnished with cross-hairs and mounted upon a swiveling base with a pointer *B* moving over an azimuth scale *C*. When the slow motion of the telescopes was arrested and one telescope furnished with one or more fore-and-aft cross-hairs pointed directly downward, it was found easy to make a peculiar reading known as the "stream-line observation."

When one is looking downward at the surface of the earth, through a tube or telescope, if, instead of looking for specific objects, he simply observes the passage of *all* objects across the field of the tube or telescope, he at once becomes conscious of the passage of all of these objects taking place in certain clearly-defined parallel lines, which I have denominated "stream-lines." When one gets somewhat familiar with this kind of observation, he can see almost nothing but these stream-lines, and the nearer the surface or greater the speed, the more tense and clearly-defined these lines become. Now, if a good, heavy cross-hair be stretched across the tube or telescope, and the tube be made so that it can be rotated upon its major axis, then it is found easily possible so to rotate the tube as to bring the cross-hair exactly coincident or parallel with the stream-lines.

The rotating tube or telescope is furnished with a stationary scale, the zero of which is coincident with the longitudinal axis of the aircraft. By taking readings on this scale with a pointer on the tube opposite the cross-hair, it becomes easy to determine the angle between the stream-lines and the major axis of the aircraft, since the latter always lies in the apparent direction of flight, the angle being between the stream-lines, or actual direction of flight, and the aircraft. The determination of such an angle as this is extremely useful, as it at once gives the aviator a clew as to what change to make in his course so that his direction of flight is such as to neutralize the drift of the medium through which he is flying, his actual course being thus brought into exact harmony with the direction required to reach his destination.

In securing this parallelism the pointer *B* is swung upon the scale *C* and the angle of drift in degrees can be immediately read on the scale from the longitudinal axis of the aircraft. Many surprises are in store for the pilot or observer when he first makes this observation, as he often is certain that it cannot be correct. He cannot believe it possible from his compass heading, to which he is holding with great accuracy, that he is actually making headway at so large an angle from its readings. And if he has had experience at sea with the compass, this impression is all the more startling, because it is always true that a ship is traveling practically on the exact course indicated by its compass. But here the pilot is holding his course absolutely true to the compass, and yet the drift indicator shows a quite different condition of affairs; namely, that he is actually traveling at a considerable angle to his supposed course.

Fig. 2 shows the instrument described mounted upon an airplane and being used by the observer. The observer in this instance is Captain Creagh-Osborne, R. N., head of the Hydrographic Office of the British Admiralty. The pilot is Lieutenant Towers, U. S. N.

With the earlier instruments the pilot would change his course and by trial in error finally reach a flight heading on the compass card, resulting in actual headway of the aircraft along the true course; that is, along the line that he was originally instructed to pursue to reach the desired destination.

Thus it will be seen that the accurate determination of drift is an important factor in aerial navigation. It is true that observations are somewhat more difficult at great heights and over rough water, but one soon becomes accustomed to obtaining a mean reading, which is found to be very accurate. It has also been definitely ascertained that when flying with the automatic pilot, with which side disturbances are practically eliminated, the streamline observation becomes very much simplified and accurate at practically all altitudes.

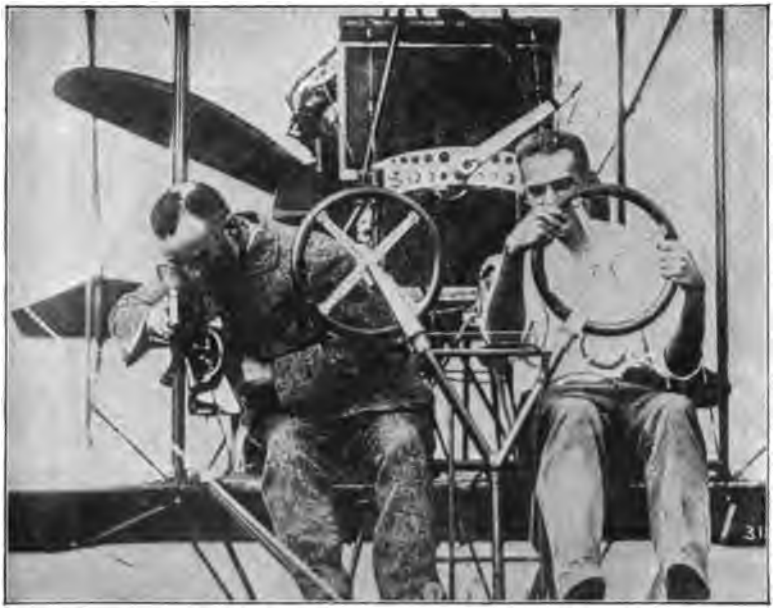


Fig. 2. 2006
Drift Indicator in Use by Navigator

THE SYNCHRONIZED DRIFT SET

A later form of the apparatus is shown in Fig. 3, in which a single stationary telescope, provided with the cross-hairs, is employed for the moving series of telescopes, inasmuch as the drift factor is found to be of far more importance than the actual speed of advance with reference to the earth's surface.

In Fig. 4 is shown a drift compass with an adjustable lubber line and with a little tiller wheel extending from the side of the case, by means of which the lubber line is set from the indications upon the scale *C* of the drift indicator. The scale upon the bezel of the compass is used for reading the deflection of the lubber line. Care must be taken in moving the lubber line to be sure that its setting is correct as to direction, and that it is not set on the right side of the zero when it should be on the left.

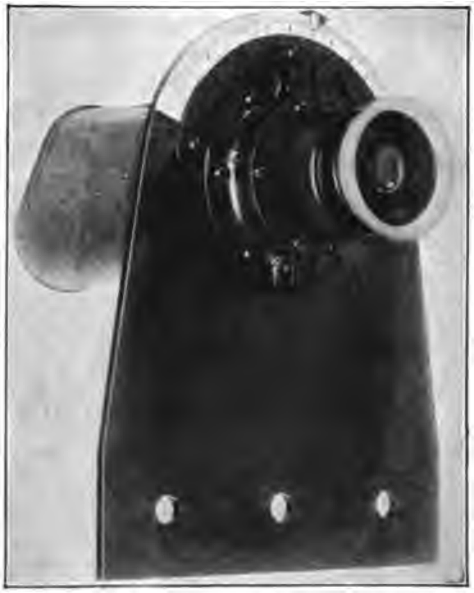


Fig. 3. 2009
New Type of Drift Indicator

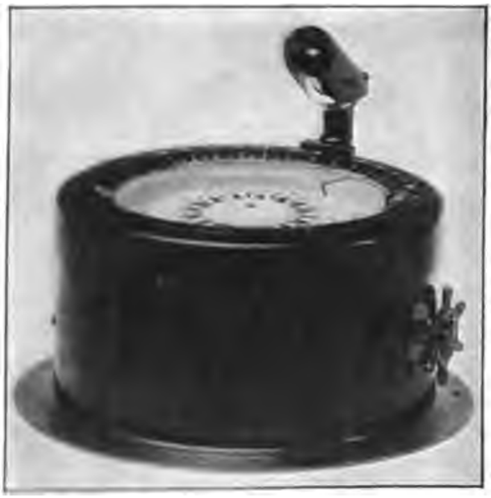


Fig. 4. 2010
Drift Compass with Adjustable Lubber Line

A pilot, especially when without the automatic pilot and working alone, has enough cares without the added one of worrying whether the compass has been accurately synchronized with the drift indicator, and whether the direction of the adjustment is also correct. So my son Lawrence conceived the idea of coupling them mechanically, in order that they might be at all times automatically synchronized. The combined instrument, namely, the synchronized drift-set has now become the most useful form of the apparatus and the one most widely adopted. In this instrument the most minute azimuth movement introduced by the observer at once causes a corresponding alteration of the position of the lubber line of the compass, thus eliminating the possibility of error either in the direction of this movement or in its exact amount. This is found very practical, inasmuch as it vastly simplifies

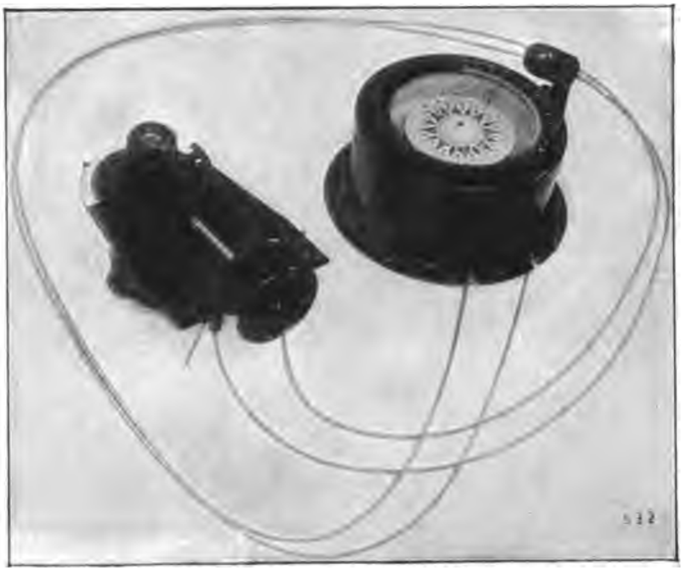


Fig. 5.
Synchronized Drift Set

2011

the pilot's operation, he needing only to continue without change to hold the lubber line upon the originally selected point on the compass card. The fact that the lubber line is displaced, especially if under the control of the observer, is something with which the pilot has nothing to do and is not concerned—he simply continues on his original compass course. This arrangement automatically introduces all of the deviations in course to correct fully for drift, and is found to save much valuable time and fuel, and to allow the pilot to reach his destination by a true meridional course. With the actual drift known and corrected for, the correction that should be given the anemometer speed, which is always known to the operator, can be determined easily. Thus he has all the knowledge of the actual forward advance that is roughly necessary in short flights.

Fig. 5 shows the synchronized drift set with the observing telescope to the left, the compass to the right, and the compass lubber line thrown around

30 deg. from the longitudinal axis of the aircraft indicated by the zero on the scale shown on the bezel. When the observer and the pilot sit in tandem relation in the aircraft, then it becomes desirable that each have a compass. We have made a number of sets, Fig. 6, in which two compasses are synchronized by means of a single drift indicator.

PRECAUTIONS IN FLIGHT OVER WATER

We will now turn our attention to some refinements of the use of this apparatus when one is flying under actual service conditions over water. It is always wise to note the direction of the wind before starting, and also something as to the length of the wave, that is, the distance from wave crest to wave crest. A pilot of seaplanes or an observer, or both, should become accustomed to estimating this wave length or distance from crest to crest, say for this country, in feet, and should also invariably note the direction of the wind in terms of compass azimuth.

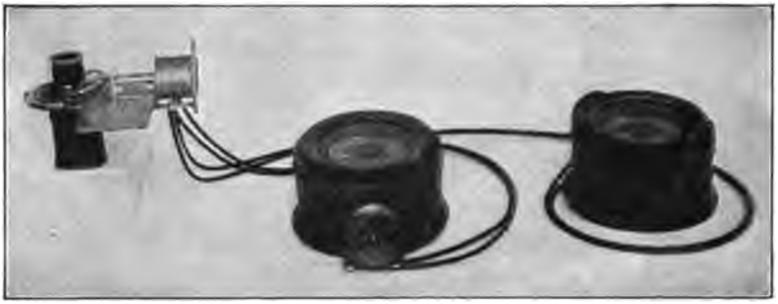


FIG. 6. 2012
SYNCHRONIZED DRIFT SET WITH TWO COMPASSES

In leaving the surface of the water, it should also be the duty of the personnel to see that the aneroid is adjusted exactly on zero. This observation should also be made whenever the plane is brought close to the surface, thus eliminating effects of changes in barometer in determining actual heights. The uses of these observations will be presently apparent. Let us now divide the problem of speed control into two classes.

In the first class stroboscope methods are used. One form of the stroboscope is shown in Fig. 1 (page 227). Another instrument working upon this principle is illustrated in Fig. 7. Still another simpler form is in course of being developed for the U. S. service. The speed with reference to the surface of the earth can be ascertained with a good degree of accuracy over water. It is, of course, necessary to know the movement of the sea, or, rather, its apparent movement, as for instance, the movement of the wave crest. In every instance the actual angular velocity of the stroboscope, or of the apparent passage of the earth's surface, and the careful reading of the aneroid are used as prime factors.

The second class is where a close approximation of the actual speed can be ascertained quickly. Using the anemometer speed as a base, we determine whether the actual speed is the same as, or greater or less than the anemometer speed, and also obtain a close approximation of how much the variation is. It is assumed that the anemometer speed is always available to the navigator. A good anemometer is known to possess a high degree of accuracy.

When the wave crests are small and cannot be seen directly, the same telescope that is used to ascertain the stream-line directions can be employed to observe the direction of the wave crest. I have had some discussion as to the visibility of the wave crests with some who are unfamiliar with it, but, as a matter of fact, the wave crests are clearly visible. Fig. 8 is a reproduction of a photograph taken from a considerable altitude, and shows how clearly visible these wave crests are. They are an excellent indicator of two valuable factors: First, from their length from crest to crest we can ascertain their speed; and second, their direction always lies directly normal to that of the wind. In all probability there also exists a reasonable relation between the velocity of the wind and the velocity of the waves, but we will not concern ourselves with this at the present time. The waves shown in Fig. 8 are about 10 ft. from crest to crest, giving us a velocity of 7.2 ft. per sec. At first glance it might be difficult to know in which direction these waves are moving, but with the conditions such as in Fig. 8, there is the simplest possible clew consisting of the vapors flowing from the funnels of the two small craft shown. The line of vapors is seen to be normal to the line of the wave crests.

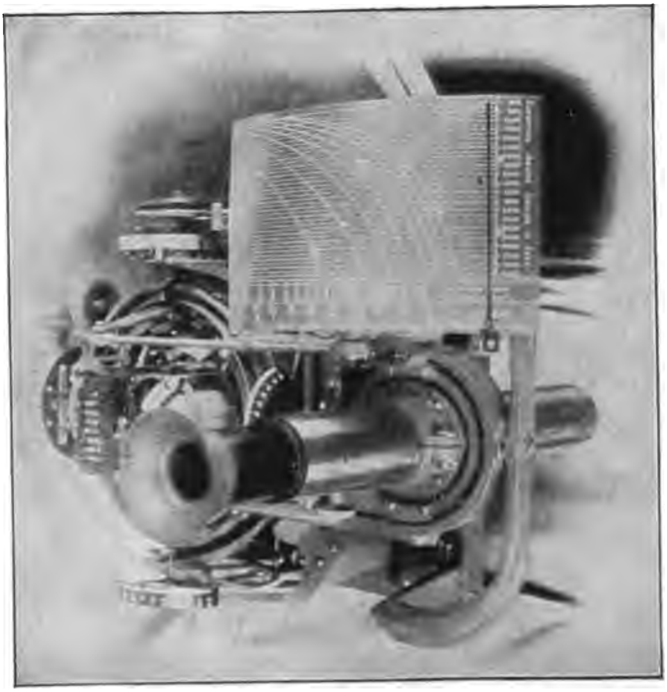


FIG. 7. 2018
SPEED INDICATOR USING STROBOSCOPE METHOD

Bearing these points in mind, the following rules can be applied to aerial navigation:

1. Note on which side of the keel line or longitudinal axis of the aircraft lies the actual or true course, or on which side of the zero on the bezel of the drift compass lies the adjustable lubber line. This is the "drift side," and can, of course, be to the right or to the left. (The zero on the bezel indicates the keel line.)

2. Note closely the apparent alignment of the wave crests while the aircraft is being maintained on its course.

3. Note the relative angle between the wave crests and the keel line, and also between the wave crests and the "drift line," or the alignment of the adjustable lubber line.

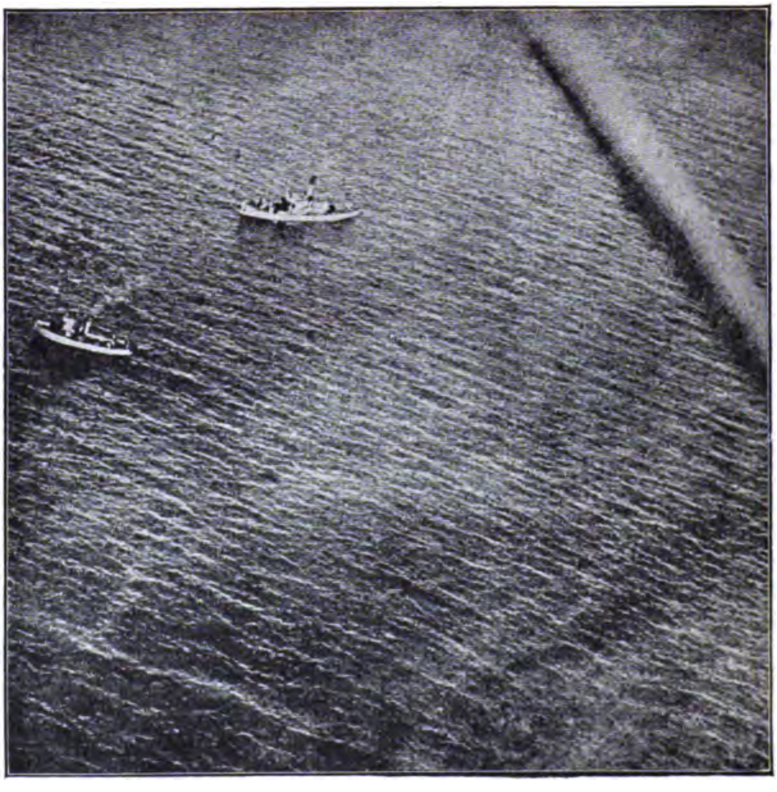


FIG. 8. 2014

WAVE CRESTS VIEWED FROM AIRPLANES

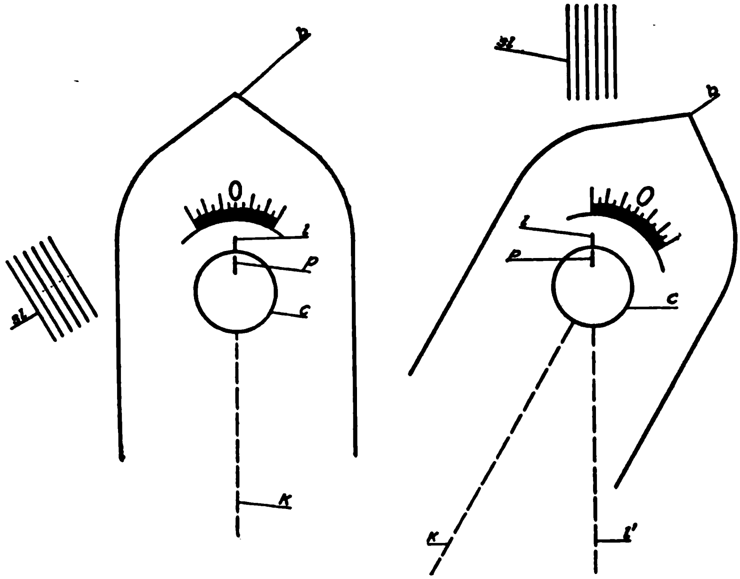
With these observations well in hand, the following deductions can be made:

a. If the crests lie within the angle between the keel line and the drift line, then the real speed is approximately identical with the anemometer speed. If these crests exactly bisect this angle, then the real speed on the actual course is exactly the anemometer speed.

b. If the aft ends of the crests be toward the drift side, then the actual speed over the earth's surface is always greater than the anemometer speed, because of an abaft wind.

c. If the aft ends of the crests are away from the drift side to a greater extent than is the true course angle or drift line, then the actual speed is always smaller or less than the anemometer speed, because of head wind.

d. If the crests lie exactly at right angles to the keel line, of course no drift angle exists, and the stream-lines lie parallel to the keel. However, it is always known which way the wind is blowing, from observations made before starting (which have been referred to), and in this manner we at once know whether we are passing over the surface of the earth at a faster or a slower speed than that indicated by the anemometer. Suppose, however, the navigator should have mislaid his data or forgotten the direction of the wind or its true azimuth. A clew to the direction can be obtained as follows: Change the course sufficiently to make the stream-lines veer away from the keel line. If the leading ends of the stream-lines are seen to move to the left for a right turn, the wind is a *following* wind, and if they move to the right for a right turn it is a *head* wind. Of course, for a left turn just the reverse is true. As to whether the velocity is great or little can easily be judged from the sea conditions.



FIGS. 9 AND 10.
OUTLINE OF FRONT PART OF FLYING BOAT

In Figs. 9 and 10, *b* is the forward part of the flying boat in outline; *k* is the keel line; *l* is the lubber line; *c* is the compass card. The zero on the compass bezel is on the keel line; *sl* indicates the stream lines and their direction; *p* is the point on the compass card indicating the desired direction of flight. In Fig. 10 *l* and *l'* indicate the "drift line," or true course.

MOVEMENTS OF THE WAVE CRESTS

As a still further refinement in ascertaining speed and direction, account should be taken of the movement of the wave crests themselves. This can ordinarily be found by determining the length between the crests, inasmuch as the velocity varies about as the square root of the wave length or distance between crests; the velocity in feet per second equals the wave length in feet at a point where each is expressed by the figure 5⅛—to be accurate, 5.123—that is, when these measure the distance from crest to crest, their velocity is also 5.123 ft. per sec. The 10-ft. wave shown in Fig. 8 would therefore have a velocity of about 7.2 ft. per sec.

We know the approximate length of this wave, having observed it before leaving the water; but if this has not been done, we can ascertain the length by dropping down near enough to the surface of the water to get a fairly accurate determination of the mean lengths between wave crests, taking this opportunity also to note that the aneroid is at zero. Having thus determined the velocity of the wave crests, we proceed to determine the necessary corrections.

CORRECTIONS FOR MOVEMENT

With reference to the speed, a correction should be made in proportion to the sine of the angle between the wave crest and the stream-line. To obtain the actual speed over the earth's surface, we should add the speed of the wave crests to the speeds obtained by stroboscopic methods in all cases of following wind, and subtract in case of head wind. The amounts that are subtracted are equal to the velocity of the wave crests only when the wave crests are at right angles to the stream-lines. At other angles the velocities subtracted or added are as the sine of the angle between the wave crests and the stream-line.

As to the influence of the moving wave crests on the apparent direction of the stream-lines, it should be noted that (a) the angle between the stream-lines and the wave crests should be determined; and (b) starting with the position where the stream-lines and wave crests lie parallel to each other, as being the condition of maximum correction, we derive this correction from the known velocity of the wave crests. The correction, it should be remembered, is an angular correction to be applied to the apparent direction of the stream-line, resulting in a refinement of heading, which gives the true meridional course to the point of destination.

This correction is always proportional to the ratio of the velocities of wave crests and aircraft determined, say by stroboscopic methods or by the anemometer, after the proper corrections have been applied. When the wave crests and stream-lines are parallel, this ratio is applied directly. When other angles obtain, the correction should be multiplied by the cosine of the angle between the wave crests and the stream lines.

One factor now remains, that is, as to whether the correction is to be applied clockwise or anti-clockwise. Assuming the observer is facing the direction of the stream-line or actual flight, then if the wind is from the right the correction should be counter-clockwise, and if from his left the correction should be clockwise. The navigator knows the direction of the wind from his original observation of its true compass azimuth before rising from the sea. If, however, this information is lacking, the direction of the wind can be found as follows:

Notice the direction of the stream-lines with respect to the keel line. If this is to the left, the wind is from the right; and if to the right, the wind is from the left. If the stream-lines happen to be parallel to the keel, then the airplane should be veered to the right or to the left until the keel line and stream-line lie at an angle to each other, whereupon the above observation can be made.

There are a number of other interesting aids to navigation of aircraft, such as clinometers, gyroscopic base lines, and artificial horizons, banking indicators, angle of incidence indicators, and the like, but their uses are apparent and need little explanation.

—*Bulletin of the American Society of Automobile Engineers.*

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THE DEVELOPMENT OF OUR FLEET AND NAVAL STATIONS[1]

By W. L. CATHCART, Philadelphia, Pa. (Member of the Society)

My subject, "The Development of Our Fleet and Naval Stations," is so broad that only a rapid review of its salient points will be possible to me.

I need scarcely say that this whole question of naval strength is one of impelling interest to engineers. The European conflict has shown in many striking ways that war by land and sea is now very largely but a matter of applied science, of physics and chemistry, and chiefly of engineering in all its branches.

Years ago, Theodore Roosevelt said, in an expression which has become classic, that the naval officer of our time is fundamentally a "Fighting Engineer." This description is wholly accurate with regard to the structures and mechanisms of naval war—its huge hulls and giant turbines, its colossal guns, its dynamos, wireless, torpedoes, and aircraft. The naval officer has added functions as a strategist and tactician, but it is clear that the engineer is a mighty factor in the sea power of our time.

WHY WE NEED A GREAT NAVY

Why does the United States need a great navy? In the first place, our country is the richest, and, owing to its vast extent of coast-line, the most vulnerable of all the great Powers. And, second, like a modern Atlas, it staggers—diplomatically and militarily—under the weight of some national policies which, while just, are as world-irritating and war-breeding as any that history has known. These policies are: The Monroe Doctrine, The Neutralization of the Panama Canal, The Maintenance of the Rights of Neutrals, The Exclusion of Asiatic Races, and The "Open Door" in China.

The Monroe Doctrine extends our "political suzerainty over two continents, comprising a fourth of the habitable earth and one-half of its unexploited wealth." Excluding Canada and the United States, this vital and yet war-inviting policy covers twenty republics, having a total area of nine million square miles, a population of eighty millions, and a foreign trade of nearly three billion dollars. And all this is to be guarded from European seizure by the force behind a doctrine which is not international law, but simply a bluff declaration by the United States that Europe shall not enter in!

This doctrine has been a sleeping danger to this Republic for nearly a century now. Its slumber has been due chiefly to the lack of means for the swift transfer of fleets and armies across the Atlantic, and the extreme delicacy of the balance of power in Europe. The progress of steam navigation has swept the first of these away, and, as for the second, who dare predict political conditions in Europe when this war closes?

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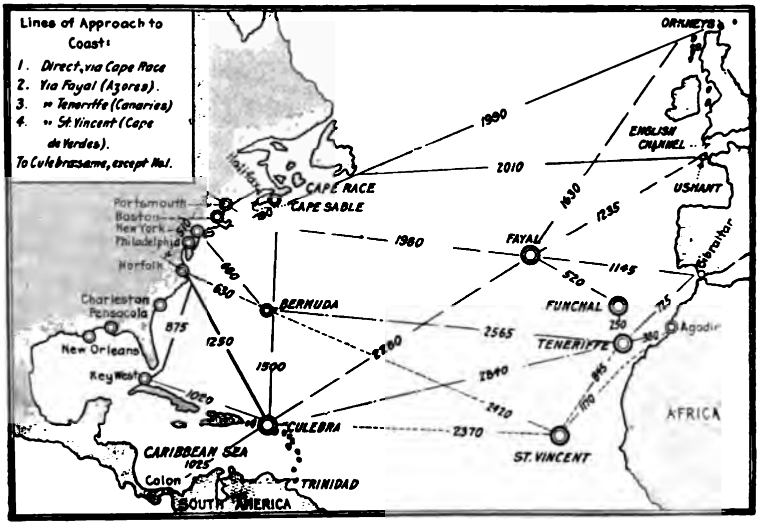
[1] Address (abridged) delivered at the Annual Meeting of the American Society of Mechanical Engineers, December 8, 1916.

Now, take the Panama Canal. By international law, it is a part of the territory of the United States, and it is also, as a military and commercial highway, one of the world's greatest prizes. So, we must defend it. Further, by the provisions of the Hay-Pauncefote Treaty of 1901, we agreed that "the canal shall be free and open to the vessels of commerce and of war of all nations"—that is, we guaranteed its neutralization. Either of these obligations necessitates a powerful, fully supported fleet, and neutralization presents as well most complex and dangerous problems for the future.

We have glanced at the possible effects of but two of our national policies, and they alone hold menace enough for the future. Trans-oceanic attack can be met primarily only by a fleet. Do you wonder, then, that naval strategists foresee a time when—not in aggression, but in national defense—the mighty thunder of American guns will roll out in mid-Atlantic or on the sun-lit Caribbean, along the coasts of Europe or at the threshold of the Far East?



Courtesy U. S. Naval War College.

2016

Fig. 1.
Partial Strategic Chart, North Atlantic Ocean

The surest way to delay the coming of that time is to have behind the parleys of our diplomacy a naval force stronger than those of our possible foes. All history shows that diplomacy, when backed by guns enough, can keep the peace, but notes without powder behind them are futile.

Strategic Situation, Eastern Coast

The elements of naval strength are: First, the fleet—its ships and men; and, second, its shore stations—navy yards at home and naval bases in our island possessions—which dock, repair, and supply the ships, and from which the fleet may strike. Manifestly, the location of these stations with regard to our possible battlegrounds of the future is of primary importance.

Let us glance briefly at the strategic situation of our eastern and western coasts in this respect, as shown by charts whose use is permitted through the courtesy of Rear Admiral Knight, President of the Naval War College, and Captain J. S. McKean, Assistant to the Chief of Operations.

When invasion by an European Power is threatened, our Navy Department will know only that the enemy has set sail from some port across the Atlantic. His specific course and objective—on our coast or in the Caribbean—will be unknown. Our fleet, if strong enough, would take the offensive-defensive, and attack the enemy a thousand miles or more at sea. To locate him, our admiral would send out a long line of scouts to scour the seas in a great arc from Cape Sable in Nova Scotia to Trinidad at the lower entrance of the Caribbean Sea.

There would be four principal points of departure for this enemy fleet: from the Orkneys, the northern base of the British Grand Fleet; from the mouth of the English Channel; from the Straits of Gibraltar; or from some point on the African coast, as Agadir.

On these four lines of approach to our coast the distances range between 2800 and 4200 sea miles. To Culebra—which, if we do not acquire St. Thomas, will be our challenging Caribbean outpost—these lines are from 3200 to 3900 miles long. In the present state of naval science, these relatively great distances make successful invasion impossible, if the enemy fleet must conduct *continuous operations* on our coast *from its home bases*, or even from these Eastern Atlantic islands.

There are two main reasons for this. In the first place, a naval force, steaming far from its bases, must be followed by a train of supply vessels, which train becomes huge when that force is large. And, second, fleets cannot invade. So the enemy fleet must be followed by troop transports.

And, further, unless the enemy had previously gained command of the sea, these helpless fleets of transports and supply ships of his must be guarded always while enroute throughout the whole period of his operations, and by a stronger force than we could bring against them.

From these considerations, several things are clear: First—disregarding the Caribbean for the time—any enemy but Great Britain must, for successful invasion, first *seize a naval base on our coast*, from which to conduct succeeding operations. To seize that base, he must first *defeat decisively* our fleet—either destroying it, blockading it, or forcing it to withdraw to a distance. Then, and then only, when the enemy has *won command of the sea, will his convoys* of troops and supplies *be safe*.

Naval bases suitable for hostile operations are fairly numerous on our coast. For example, Delaware Bay, Narragansett Bay,[1] Provincetown, Mass., and several others, in their present defenseless state, could be seized with ease if our fleet were first defeated.

As to our naval stations on this coast, they all lie within an air-line distance of 500 miles, although our Atlantic and Gulf coast-lines are more than 3000 miles long.

If an enemy should gain possession of these 500 miles of coast, our dreadnoughts would be homeless, unless the fleet could flee to the Bay of Panama, since the yards at Charleston, Pensacola, and New Orleans are equipped for small craft only. As to these conditions, Rear Admiral Edwards says:

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[1] It is believed that the seacoast forts at the entrances to Narragansett Bay are sufficiently strong to require a landing in force for an attack in the rear before the Bay could be occupied

"There is not a dry dock owned by the Government or by anyone else on the South Atlantic and Gulf coasts which will take any of our super-dreadnoughts. There is not a single stationary or floating crane on these coasts which will remove from or install in a battleship either a modern turret gun, a Scotch marine boiler, or an assembled low-pressure turbine of the kind now fitted in our large naval colliers, tankers, and battleships."

These conditions give our strategists just cause for concern in their bearing on our undefended line of communications, 875 miles long, from Cape Hatteras to Key West, and on the distance, one-half greater, from Culebra to Norfolk.

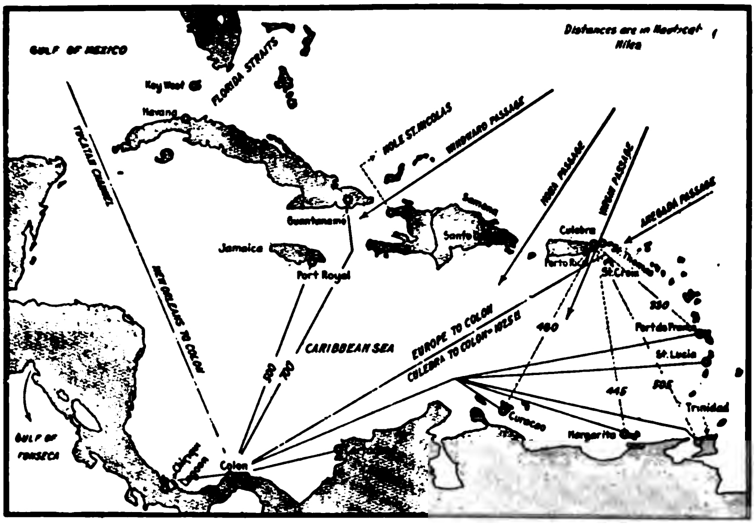


Fig. 2.
Strategic Chart, Caribbean Sea

2017

Strategic Situation, Caribbean Sea

The Caribbean Sea is—as Admiral Mahan once wrote of it—"pre-ëminently the domain of sea power." For its size, it has more strategic positions than any other important expanse of sea on the globe. For the United States, its mastery in war is almost vital, since that mastery is the bulwark of our defense of the Monroe Doctrine and the Panama Canal.

No invasion of the United States is possible until our fleet has first been put out of the reckoning. If, then, the enemy must thus eliminate our fleet, it seems probable that he would endeavor to force action where our naval strength is most vulnerable—that is, off Culebra, where our ships would be more than 1200 miles from their home bases.

Again, *for continuous operations*, the enemy must have a naval base of his own on or near our territory, and the seizure of a small island would be far easier than that of a base on our coast.

Finally, if thus established at some point like St. Thomas or Culebra, with our fleet negligible for the time, the enemy could raid our South Atlantic and Gulf coasts at will; could flank all our routes to the Caribbean, and when—with full command of the sea—his convoys of troops had come he could invade the Canal Zone, 1040 miles from St. Thomas. Possession of the Canal would give him not only a powerful lever in bringing pressure on our Government, but would enable him to block the retreat of our defeated fleet to Gatun Lake or the Bay of Panama, and to prevent the coming of reinforcements from the Pacific.

Glance now at the geography of the sea. On its northern border lie Porto Rico, which we own; Haiti and Santo Domingo, which are under our virtual protectorate, and Cuba, whose independence we have guaranteed. Doubtless, every port in these islands would be open to our use in time of war.

There are five entrances to the sea along this northern border—the Yucatan Channel via the Florida Straits from the Atlantic, and the Windward, Mona, Virgin, and Anegada Passages. Dominating the Florida Straits stands Havana like a new-world Gibraltar. Near the southeastern end of Cuba lies our base, Guantanamo, which, with Mole St. Nicolas in Haiti, commands the Windward Passage. Similarly, Samana Bay in Santo Domingo controls the Mona Passage, Culebra and St. Thomas the Virgin Passage, and the latter and St. Croix the Anegada Passage, which is the main route from Europe to the Canal.

Jamaica, with its naval base, Port Royal, seemingly dominates all by its central location. But, while Jamaica has thus a commanding strategic position, it is lacking in strength against attack and in its resources for supplies and refitting. Hence, for military support and supplies, it would be dependent in war on its lines of communication with other British colonial and home ports, and from those ports it is both distant and isolated. Further, our base at Guantanamo flanks its communications with all of these ports.

Now as to our two naval bases, Guantanamo and Culebra: Guantanamo is but 700 miles from the Canal, and, as it flanks all routes to Colon except that from Jamaica, its location centrally is almost as good. Further, it has surpassing advantages in the fact that it is on a large island, which has not only great native resources, but also direct railway communication with manufacturing centers in the United States except for the short sea link between Key West and Havana. Hence, supplies can reach Guantanamo by interior land lines immune from attack by sea if the Florida Straits be guarded effectively.

As compared with Guantanamo, Culebra is about 600 miles farther to the eastward, and hence it has a far better command of the eastern entrances to the sea, flanking all routes through them by short runs of 350 to 500 miles. Again, it is but a few miles from Porto Rico, which is in itself difficult of defense. Further, as a little island, it could be fortified and garrisoned at proportionately low expense. And finally, as a salient, it flanks the lines of approach to our coast.

All of these advantages, and more, hold for St. Thomas, just across the Virgin Passage from Culebra. It also is a small island, it is still farther eastward, has a better command of the Anegada Passage, and its harbor can be strongly defended by fortifications in the high hills surrounding it. The best argument for its acquisition by the United States is, however, the negative: Suppose the unthinkable—that we should let St. Thomas pass into the hands of a strong military power unfriendly to us. Then our base at Culebra would be confronted by a rival fortress on the further shore of that narrow Virgin Passage. These conditions would be as if

Gibraltar faced an equally formidable and alien "Rock," with but the Straits between.

And *the menace of that fortress would stretch far beyond the Caribbean* to our trade routes to South America, and even to our coast. For within a radius of 1000 to 1400 miles from it lie New Orleans, Key West, Charleston, Norfolk, and New York—a distance through which raiding battle-cruisers or even a dreadnought fleet could steam and fight, with ample fuel remaining for their return, if necessary, to St. Thomas.

We find, then, that the destiny of nations has given the United States full opportunity for holding the strategic mastery of the Caribbean Sea through its present and prospective tenure of predominating positions there. But strategic dominance on the sea means nothing if the sites on which it depends are not fully equipped, fortified, and garrisoned and an adequate fleet based there, since a more powerful enemy would simply wrest them from us. So these neglected West Indian bases of ours give cause for grave concern. *With them, some day, the fate of this Republic may rest.*

STRATEGIC SITUATION, NORTH PACIFIC

Let us close our strategic review with a brief consideration of our western coast and our outlying possessions in the North Pacific Ocean, where remarkable conditions exist.

In the first place, the United States owns on the shores from Panama to Kiska in the Aleutian Islands every important strategic position except three—the Galapagos Islands, Magdelena Bay in Mexico, and Esquimault, the fortified port of British Columbia. Thus, strategically—if these be developed—our power over these shores is predominating for two-thirds the width of that great ocean.

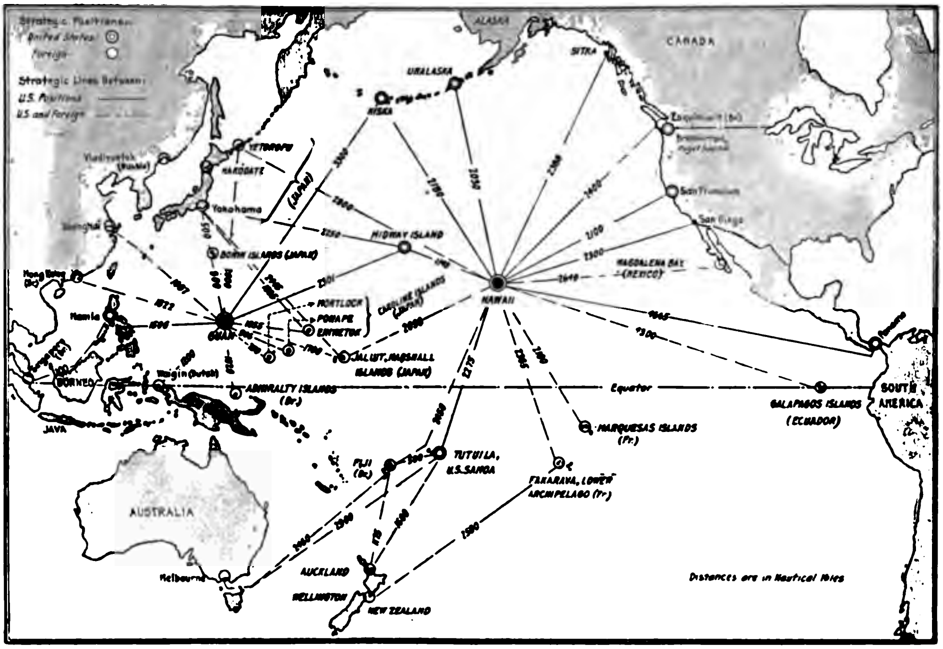
Further, spanning the Pacific like the piers of a colossal bridge from Panama lie our islands of the Hawaiian Group, and our other Island, Guam, in the Ladrones, which is *the key to the military control of this northern ocean.* Then 1150 miles west of Hawaii is Midway, useless to us except as a future coaling station. And finally, 2300 miles southward, is Tutuila in American Samoa, one of the noblest harbors in the South Seas.

Steaming at 12 knots an hour from Panama, it would take a fleet 12 days to reach San Francisco, 16 days to Honolulu, 28 to Guam, and 33 to Manila. So no fleet stationed on our western coast in war could protect the Philippines and our interests in the "Open Door" in China. Hence, *for their defense and that of Alaska*—which is virtually an overseas possession 2000 miles from San Francisco—*we must rely on our Island bases, Guam and Hawaii.*

Hawaii is the center of communications—*the strategic focus*—of the eastern half of the North Pacific Ocean. This means that a fleet based there can strike with equal ease, in offense or defense, at all points on the great arc of coast-line from Kiska to Panama. *Hawaii thus dominates the whole strategic front formed by the shores of the eastern half of the North Pacific Ocean.*

Similarly, the strategic lines of the western Pacific all intersect near our possession, *Guam, which is thus the strategic focus of that half of the ocean—and hence a menace in war to every important position there,* from Japan's northernmost one at Yetorofu and that of Russia at Vladivostok, down the Chinese coast to Singapore in the Straits Settlements. Well within the circle of Guam's protective area lie the Philippines, indefensible of themselves, whose single stronghold is the little island, Corregidor, in Manila Bay. And also, well within its reach, stands that—now closing—"Open Door" in China. Guam is small—about seven by twenty-nine miles—has a harbor which, by dredging and building a breakwater, would shelter a fair-sized fleet, and is readily capable of defense by fortifications and mines.

Finally, a noteworthy fact as to our chain of bases bridging the North Pacific, is that the strategic line from Panama through Hawaii to Guam cuts the similar British line from Esquimault to Australia and New Zealand. In view of this and of the focal relations of Guam and Hawaii to that northern ocean, *the strategical predominance of the United States in those waters is* —in a geographical sense, at least—*unquestionable.*



Courtesy of U. S. Naval War College.

Fig. 3.
Partial Strategic Chart, Pacific Coast

2018

Guam and Hawaii, if made ocean fortresses, would be our Malta and Gibraltar against aggression by any enemy sailing from the Far East—from Vladivostok, Yokohama, or Singapore. If in war we had strong fleets based there, no enemy from Asiatic waters would dare to pass Guam without masking or reducing it, and destroying or dispersing its fleet. And, later, he would have a similar victory to win off Hawaii before the Pacific coast would meet the shock of war. And yet, like Guantanamo and Culebra, Guam lies neglected and undeveloped there, at the very threshold of the Far East—an easy prey for any foreign nation which would dare war with us to take it. And, too, the fortification and equipment of Hawaii proceed but slowly.

As to the very striking relation of these ocean outposts to Pacific coast defense, Captain McKean, formerly of the Naval War College and now Assistant to the Chief of Operations, says:

"With Guam converted into a Pacific Gibraltar, Honolulu . . . becomes a secondary base, and can be less strongly held against attack from the west. . . . In effect, their (Guam and Honolulu) fortifications would be an expanded and intelligently elaborated coast defense, which, combined with an adequate fleet to bind them together, would keep the enemy from ever approaching our coast."

THE NEEDS OF OUR NAVAL STATIONS

In the upbuilding and maintenance of the Navy, we shall need all the navy yards we have—and more. As a whole, these yards lack much, not only in the dredging of their channels of approach, but in modern equipment for building and repair, both as to hulls and machinery. The need of dry docks and of channels to these yards, which would be deep enough for our largest vessels at all stages of the tide, is an amazing instance of naval unpreparedness. We have been building, and are to build, giant dreadnoughts, which, at present, can be docked at only four widely separated navy yards—New York, Norfolk, Puget Sound, and Hawaii. The possible consequences, after but one great naval battle, are appalling. I have pointed out the imperative need of repair facilities on our southern Atlantic coast for war vessels of the largest size. At present, Charleston seems to be the only suitable location there. Admiral Benson, Chief of Operations—in recommending a navy yard of the first-class on this southern coast—says, if "there should be any naval engagements south of Hatteras, it would be of vital importance to be able to use all the facilities that the Charleston yard offers"—and that yard is now but a very minor affair.

As to the naval bases for the defense of our outlying possessions and as frontier outposts for our coasts, the admirable locations which we now have are as yet but "the substance of things hoped for," and fatally lacking in much.

Admiral Knight, President of the Naval War College, says: "It is my opinion that the completed bases at Guam and Culebra, including the defenses * * * would cost in the neighborhood of $15,000,000—in other words, about the price of a battleship." Shall we hazard the safety of our fleet and imperil our national defense to save an amount equal to the cost of but one dreadnought?

Every important naval station on our coast and island possessions should have its Flying Base and be equipped also with its "Mother Ship," carrying from ten to twenty aeroplanes, all fitted with wireless. These flying scouts could report the location and formation of an enemy fleet some days in advance of its appearance off the coast.

HOW LARGE SHOULD OUR NAVY BE?

Not for aggression, but to keep the peace, and to exert fitly what Mahan called "the silent force of sea power," the United States needs a great Navy. How big should that Navy be?

Several conditions affect the answer. First, our unequaled and ill-defended wealth, inviting spoliation. Second, our immense territory, which—from Eastport, Maine, to Manila—stretches more than half around the world. Third, the factor of distance with regard to that territory—which factor has no parallel in Europe. England, for example, is today waging the greatest naval war of all history at but 400 miles from her own shores, while, with us, the distances to the Caribbean Sea, to the Panama

Canal, to Alaska and the Philippines, are from three to twenty times greater. Fourth, the fact that "the United States Navy is really a 'Disunited States' navy," since, like Russia, with her Baltic and Black Sea littorals, we have two widely separated coasts, linked, in our case, by a canal which may fail us in a crisis—either by slides or by treacheries or direct attack with high explosives on its locks.

It would take 60 days for our fleet to steam from the Caribbean Sea around South America to Panama. The Austro-Prussian War of 1866 was won at Sadowa in nineteen days after its beginning. The Franco-Prussian War of 1870 ended at Sedan in fifty-one days after its declaration. The British Fleet—the very keystone of Allied success in the existing war—was started instantly on its fateful run of but 400 miles by the telegraphic order, "Go!" By sixty days' delay in sudden war we might lose the lands of an empire—Alaska, Hawaii, Guam, and Samoa—in the Pacific Ocean.

Hence, from every viewpoint—of strategy and of common sense—the conclusion is inevitable that we should keep permanently in each ocean a battle fleet strong enough to defeat decisively any probable enemy there.

This in itself means a great Navy, but the General Board states that we should go farther still, that "the Navy of the United States should ultimately be equal to the most powerful maintained by any other nation of the world."

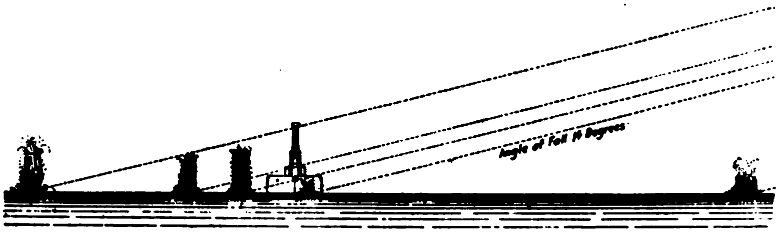


Fig. 4. 2019

Effectiveness of Salvo Firing of a U. S. Dreadnought

(The extreme splashes ape 400 yards apart. In the position shown, three shots would have struck a battleship.)

Modern Battle Ranges

The great growth in the possible battle range during recent years has been forced by the increase in torpedo range, which, officially, is now 10,000 yards (5.7 miles), but probably is considerably more.

Since guns can now hit with straddling salvos as far as the fire control officer in the top can see the decks of the enemy ship, the question of the limiting battle range is now in theory one of visibility only—of extending, instrumentally, the range of human vision beyond the horizon which the curvature of the earth makes.

In discussing this subject, Commander Ralph Earle of our Navy gives the distance of the sea horizon from the turret sights as 11,400 yards (5.7 sea miles) in perfectly clear weather. But the "spotter's" platform at the top of the mast of an enemy ship would be about 110 feet above his sea level, and hence would be visible—just above our turret-sight horizon—for a distance of 12 sea miles more, making the total distance of visible objects 17.7 sea miles, or 20.4 land miles (35,400 yards).

However, other conditions than visibility affect this fighting limit.

These are, first, the small percentage of hits at extreme ranges; and, second, the wearing out of the guns by erosion of the bore.

The British, during the battle off the Falkland Islands, scored but two per cent of hits out of a total of 750 shots. As to erosion, it is due primarily to the high temperature of the exploding charge and the friction of its gases, although chemical action probably plays a part. With nitroglycerine powder, this temperature reaches 3178 deg. Cent. The propelling powder used by our Army and Navy is a low explosive of the nitrocellulose type, which has less tendency to burn out the bore of the gun. Owing to erosion, the accuracy-life of our 12-inch, 45-caliber naval guns is but 120 rounds. * * *.

In view of these facts many gunnery experts believe that, under present conditions, no battle, broadside to broadside, is probable at a greater range than 8 miles (14,000 yards), if closer action can be forced, since no admiral would be justified in wasting his ammunition and wearing out his guns by firing at a greater distance. In chasing, however, guns will doubtless be fired at any range at which a hit is possible.

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The battleship has been the backbone of every fleet since navies existed. There is nothing else on land or sea which is its equal in the concentration of enormous power. The energy of one 14-in. shell is, according to Admiral Fiske, equal to that of 60,000 muskets. On this basis, the 12 guns of the battleship *Pennsylvania* are equivalent to the aggregate musket-energy of 720,000 men. Each of her 14-in. projectiles has a muzzle energy of 70,000 foot-tons. Under stress, her main battery of twelve 14-in. guns can be fired about three times per minute—a delivery of 2,520,000 foot-tons during that period.

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The general method is: (1) The range of the enemy ship is found by the range finder and its bearing by the gyroscopic compass. (2) Two sets of these observations, with a known interval between, give the data required to compute the enemy's speed and relative course, and the rate of change of range. (3) Instrumental observations are checked by "spotting"—that is, observing the fall of the shell, which usually makes a splash about 200 ft. high, visible in a clear day for 15 miles.

Our Naval Strength

The battleship has been the backbone of every fleet since navies existed. There is nothing else on land or sea which is its equal in the concentration of enormous power. The energy of one 14-in. shell is, according to Admiral Fiske, equal to that of 60,000 muskets. On this basis, the 12 guns of the battleship *Pennsylvania* are equivalent to the aggregate musket-energy of 720,000 men. Each of her 14-in. projectiles has a muzzle energy of 70,000 foot-tons. Under stress, her main battery of twelve 14-in. guns can be fired about three times per minute—a delivery of 2,520,000 foot-tons during that period.

These are, first, the small percentage of hits at extreme ranges; and, second, the wearing out of the guns by erosion of the bore.

The British, during the battle off the Falkland Islands, scored but two per cent of hits out of a total of 750 shots. As to erosion, it is due primarily to the high temperature of the exploding charge and the friction of its gases, although chemical action probably plays a part. With nitroglycerine powder, this temperature reaches 3178 deg. Cent. The propelling powder used by our Army and Navy is a low explosive of the nitrocellulose type, which has less tendency to burn out the bore of the gun. Owing to erosion, the accuracy-life of our 12-inch, 45-caliber naval guns is but 120 rounds. * * *.

In view of these facts many gunnery experts believe that, under present conditions, no battle, broadside to broadside, is probable at a greater range than 8 miles (14,000 yards), if closer action can be forced, since no admiral would be justified in wasting his ammunition and wearing out his guns by firing at a greater distance. In chasing, however, guns will doubtless be fired at any range at which a hit is possible.

The Marksmanship of Our Navy

A battleship is essentially but a mobile gun platform, and its ability to hit with that primary weapon, the gun, is virtually its sole reason for existence. Occasionally there appear in the press adverse, and usually uninformed, criticisms of the Navy's target practice, of the failures of our "Hitless Navy." The facts, however, as furnished by Admiral Fletcher, tell a different story. In the salvo firing of one of our dreadnoughts in West Indian waters last winter, five shots were fired simultaneously at the same moving target, 30 ft. high by 90 ft. long. The results were photographed. The distance between the extreme splashes in the line of fire was taken as 400 yd.—the maximum dispersion of our projectiles in the line of fire. In one position between the extreme splashes, three shots would have struck a battleship, and in almost any position between she would have been hit by two or more shots.

This salvo was fired at a range of 9000 yards (5.1 land miles), with reduced charges so as to give the same angle of fall as that with a full charge at a range of 16,350 yards (9.3 miles). The hits for these two ranges would thus be the same, since all conditions as to aiming would be identical except the apparent size of the target, which does not matter with the telescopic sight. The firing ship was steaming at high speed, 15 knots. The target was towed at 6 or 7 knots on a non-parallel course, so that the range was changing constantly.

Admiral Fletcher also refers to some later practice, in which one of our ships made seven hits on this small target out of 42 shots. The ship was the battleship *Michigan*. Her commanding officer, Captain Brittain, stated that he opened fire at 18,000 yards (10.2 miles), and continued at an average range of 16,000 yards (9.1 miles). As before, the firing ship was moving at 15 knots and the target was towed on a non-parallel course.

This shooting has not been surpassed—if, indeed, it has been equaled—by any navy, and we are warranted in the belief that the *Michigan* and her consorts are making our dreadnought fleet the equal of any in the world in marksmanship. The nation hears little of their work in this, since the reports of target practice are confidential. The two examples I have given were revealed only by statements drawn from officers by the House Committe on Naval Affairs.

Fire Control

The accuracy of the target practice which has just been described is due primarily to fire control, which is vital to precision in modern gunnery, and hence to victory in a sea fight. For example, compare the *Michigan's* abnormally high percentage of hits with the similar results of the battle of Santiago. There, under the old hit-or-miss methods, our fleet fired 9000 shots at relatively short range, and made but 120 hits, or 1.3 per cent.

The reasons for this amazing inaccuracy—common to all navies then—were, as Captain Sims says, because "each gun pointer estimated the distance of the enemy for himself, made his own estimate for deflection (*i.e.*, the speed of the enemy across the line of fire), decided at what point on the ship's roll to fire, and how fast his line of sight was moving across the target and consequently how far his line of sight should be off the target (approaching it), when he pulled the lock string. It was because no man could acquire this skill to a high degree, and, particularly, because no group of pointers could acquire it to the same degree, that we could not hit anything except at very short ranges."

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Essentially, the dreadnought battleship is, first, an all-big-gun ship—that is, it has a main battery of the same caliber throughout, whose guns are capable of piercing modern armor belts at battle ranges; second, it has a speed of 21 knots or more, so as to be capable of acting in company with other dreadnoughts; third, it has the maximum armor protection which is possible with this armament and speed. The battle-cruiser is a modified battleship, having roughly about three-fourths the latter's armament and armor and about 50 per cent more speed.

Now, no nation will attack us with any but a dreadnought fleet, and only dreadnoughts can fight it. Hence, our naval strength lies fundamentally in the number and relative power of our dreadnoughts. At the beginning of the European War great Britain had, built or building, 38 dreadnought battleships, of which she has since lost one; similarly, Germany had 20, of which she has probably lost one; and the United States, 12.

As to dreadnought battle-cruisers: Great Britain had 10, of which she has lost 3; Germany, 9, but 3 have been sunk and one sold to Turkey; and the United States, none.

The relative dreadnought strength of battleships and battle-cruisers, based on pre-war figures and deducting losses, is, then: Great Britain, 44; Germany, 24; and the United States, 12.

No one outside of England or Germany knows what they have built or are building since the war started. There have been persistent reports, however, as to feverish energy in ship-building in both countries, and Germany has ample facilities for building at the rate of 25 dreadnoughts a year, while England could probably double this figure under stress.

So the United States has a hard road to travel to reach even second place among the navies of the world. It is true that, since July, 1914, we have laid down 3 dreadnoughts, that the keels of 2 more will soon be laid, and that 4 more have been authorized for immediate construction. But it takes at least three years to build a battleship or battle-cruiser, so that the last of the total of 16 dreadnoughts authorized by the recent Naval Appropriation Act will not be completed before 1922—at which time our dreadnought strength will be 27, as against the pre-war strength, deducting losses, of 44 for Great Britain and 24 for Germany.

And this is not all. A well-balanced fighting fleet includes cruisers, destroyers, and submarines, in addition to battleships and battle-cruisers. The cruiser has two functions: First, the protection of commerce; second, as a scout and for general service with a fleet. In future fleet actions, if we shall not have enough battle- and scout-cruisers to force the enemy's screen and ascertain his strength and formation, our fleet will be blind and helpless. From all viewpoints an adequate increase in our cruiser strength is imperative, and this increase should far exceed what is proposed now by the Administration and Congress—not by naval officers who know our needs.

The question of destroyers is even more pressing. Primarily, the destroyer's function is torpedo attack on an enemy fleet in battle. It can act also in protecting commerce and as a scout in moderate weather. But its surpassing service during this war has been in guarding Allied battleships from submarine attack.

England's pre-war proportion of destroyers to battleships was about 1, and this number she has found far too few as time went on. It takes of them to convoy a battleship, and it took all she had at first to guard her Grand Fleet off the Orkneys, leaving her 1800 miles of coast-line wide open for submarine attack on merchant vessels. To the British lack of these small, swift, and handy craft is due very largely her great losses of merchant vessels.

In 1922 our proportion of destroyers to battleships will be short by about 100 vessels of the British pre-war proportion of 4 to 1. Our deficiency with regard to the present proportion in the British fleet must be far greater. And yet, as the recent raid of the U-53 off Nantucket Shoals proves, we may need them in swarms on our 3000-mile eastern coast-line. We might better lack a dreadnought or an adequate fleet of submarines of our own than a strong force of destroyers.

As to submarines: The coast-defender type has shown its value during this war, and an adequate force of these vessels—not exceeding 800 tons' surface displacement and operating from protected bases—would worry an invading fleet seriously, and force it to make ceaseless attempts to trap or sink its under-water foes.

The fleet submarine—the large boat which, submerged, could charge with the fleet in action—is still but a dream. Her requirements are beyond the present state of the art. The ardent desire of every navy is to have such a vessel, with an engine exhaust which will not leave a white trail on the surface to betray her. She will surely come some day. Captain Simon Lake, the Nestor of submarine inventors, writes me:

"The high-speed submarine is going to come. How soon, I do not know. I do not believe anyone else can answer that question, as it all depends on the engines. Germany is, in all probability, away ahead of us in engine development today, but progress is being made, and as soon as we can get reliable high-powered engines, we shall have reliable high-speed submarines capable of accompanying a fleet."

Admiral Fiske's Greeting

When this paper was projected I wrote to a distinguished officer of our Navy, Rear Admiral Bradley A. Fiske—whose frank and fearless statements as to our naval unpreparedness stirred this country like a bugle-call—and asked him if, in view of the engineer's relation to naval war, he would favor me with a message to this great national body of engineers, through its representatives here assembled. In answer, the Admiral writes:

I am very glad indeed that you are going to address the American Society of Mechanical Engineers on "The Development of Our Fleet and Naval Stations."

There are no other men in the United States so immediately and directly powerful in developing the fleet and naval stations as the engineers. While the strategist estimates the general situation, and determines the application of the general principles of strategy to each situation as it arises; and while the tactician handles the units of personnel and material in actual battle and in preparation for it, it is the engineer who provides the strategist and the tactician with the mechanisms with which to carry out their respective and collective aims.

It is the engineer who enables the strategist and the tactician (and who often forces the strategist and the tactician) to keep his art abreast of the developments of the physical arts and sciences, and to take advantage of them. It is the engineer who has given to the world the gun, the torpedo, the submarine, the battleship, the wireless telegraph, the searchlight, and the aeroplane. It was the original military engineer—the youthful David, afterwards king—who made the first recorded triumph of science and art over mere physical strength, when, at a distance great in those days, he killed Goliath with his sling.

Therefore, for the reason that the engineers of any country have so much power to exert for the safeguarding of their country, and because men are always responsible for the power committed to their keeping, it is the high duty of all American engineers, and of you gentlemen who represent them, so to direct this power as to secure the peace and prosperity of the United States.

With respectful salutations to the Society, I am,

Ever sincerely yours,

(Signed) **Bradley A. Fiske.**

—*The Journal of the American Society of Mechanical Engineers.*

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DESIGN OF SUBMARINES—SUITABILITY OF CURRENT DESIGN OF SUBMARINES TO THE NEEDS OF THE UNITED STATES NAVY[1]

By Captain W. L. Rodgers, U. S. N., Associate

In accepting the invitation which the secretary of the society did me the honor to extend in asking me to contribute a paper on submarines, I do not assume that he had any idea that I would undertake to tell the members of this society anything in regard to the technical and mechanical features of submarines, with which they are already well acquainted.

But I was president of the Naval War College some years ago, and ever since I have given attention to the strategic and tactical fields of work which are open to submarines in naval warfare. A sketch of these fields and a consideration of possible modifications and variations in design of submarines to meet the requirements of warfare seem to me to offer interest to naval architects, and it is along these lines that this paper will be developed.

In thus discussing the subject, it must be borne in mind that while the constructional and engineering possibilities of design are pretty well known, and form a stock of knowledge common to designers of all nations, nevertheless the application of this stock of knowledge to the production of concrete designs suitable to the national policy and geographic situation of particular nations will result in types of ships which will differ much according to nationality. This paper will consider some of the controlling factors which should influence American design. In so doing we need not fear the betrayal of any national secret. It is the business of foreign navies, through the agency of their general staffs, not only to study in advance the requirements of their own forces, but also to examine the situation of her powers which may become hostile to them, so as to draw deductions o the enemy's probable efforts and employment of his forces.

Any enemy in thus considering our types of submarines and their prob- e employment in war will no doubt start from very much the same premises as we ourselves assume, namely, the well-known constructional possibilities of submarines varying with the progress of invention, the tactical development of the present war in attack by, and attack upon, submarines; and, finally, the national policies and geographic situation of the United States.

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[1] Paper read at the 24th general meeting of the Society of Naval Architects and Marine igineers, held in New York, November 16 and 17, 1916.

Assuming the enemy has equally good reasoning power as ourselves, and granting he knows the ordinary constructional data as to submarines, it is clear that he will necessarily arrive at conclusions much like our own. If we avoid general discussion in the hope of withholding information from foreigners, it is ourselves who will suffer most, since good will and a common understanding between the seagoing navy and the industries which support it are essentials to success, and particularly necessary in a democratic nation. In fact, a basis for such a common understanding is provided in the public hearings upon the Naval Appropriation Bills, which give much information as to our policies and views.

The purpose of this paper will, therefore, be first to examine the peculiar military characteristics of submarines in general and compare them with those of other types of combatant ships; second, to consider how these general characteristics will influence or control the employment of submarines in war; and, finally, what particular types of submarines seem best suited to American needs.

Submarines are armed with torpedoes and with guns. Owing to the great percentage of the displacement which is necessarily devoted to the heavy hulls and very heavy machinery installation, the speed of submarines is much less than that practicable for surface craft of the same size. Consequently submarines, unlike torpedoboats and other fast craft, cannot rely on their speed as a means of safety. For the submarine the chief means of defense is provided by her submersibility and consequent invisibility. Further, the great weight of storage batteries forbids giving submarines more than a small radius of action when submerged. The submarine obtains information only when able to see—at the surface. She can navigate freely and recharge her storage batteries only when running the oil engines at the surface. These are the chief peculiarities which affect the combatant powers of submarines. They affect alike those submarines which are armed with torpedoes and those of that other type, the fruit of the current war, which are designed as mine layers. Bearing these peculiarities in mind, we may proceed to consider the general principles which these qualities require a captain to observe in the employment of a submarine under his command.

In regard to the torpedo, a peculiarity exists which differentiates its use very much from that of the gun. The initial velocity of a projectile from a high-power gun is 3000 ft. per second. The speed of the fastest ship is not over 60 ft. per second. As these two velocities are in the ratio of 50 to 1 a ship cannot escape from a projectile fired at her. The greatest velocity of an automobile torpedo seldom exceeds about 40 miles an hour, and this only for moderate ranges. By reducing the speed to 30 miles or less an hour the compressed air in the flask can drive the torpedo further, but such speeds are of the same order of magnitude as those of the target ship. Consequently, the direction and speed in which the target ship is moving are most important elements in deciding when she is within range. Consider, for instance, a 30-knot torpedo capable of running 10,000 yards. If fired at a ship approaching at the rate of 20 knots there is a chance of hitting if fired at a distance of over 16,600 yards, whereas if the target is withdrawing at 20 knots the torpedo will exhaust its motive power and stop before overtaking the target if fired from any range above 3300 yards.

When submerged the submarine itself also is limited both in speed and radius—12 miles at most at 10 or 12 knots, 100 miles, more or less, at 5 or 6 knots. Thus when submerged the submarine's area of action resembles that of the torpedo which it carries as its chief weapon. It cannot chase to advantage when submerged. We cannot give a submarine the highest surface speed because of the heavily built hull and the heavy storage batteries. Such surface speed as we are able to confer on a submarine is inadequate for the tactical requirements of battle. It may enable a submarine to assume a favorable position for submerging ahead of an approaching enemy, but it cannot be great enough to be satisfactory in the tactical approach, as is the case with the torpedoboat at 30 knots, which relies upon her great speed as a means of protection when charging upon the enemy. As the submarine when submerged cannot hope to overtake its target it must lie in wait for the target to come to it.

Thus limited to moderate surface speed and low submerged speed, and unable to increase weight by the addition of armor, the submarine is obliged to rely upon her faculty for concealment as her chief means for employing her weapon, whether mine or torpedo. But concealment entails disadvantages. In hiding herself she becomes blind, and if by the adoption of the periscope she has recovered partial sight, she has sacrificed a corresponding measure of invisibility. Before concealing herself to attack, the submarine first must sight her enemy in order to direct her attack. To accomplish this to best advantage she must rise and search the horizon with natural vision. Unfortunately when doing so she cannot promptly submerge, and is therefore liable to surprise attack. The submarine's difficulty in seeing has consequences which extend beyond the individual ship. In warfare there is a combatant advantage in superior numbers which is greater than the numerical ratio of the hostile forces (as may be mathematically shown). For this reason it has always been reckoned a great point, both ashore and afloat, to bring superior forces to engage simultaneously upon the field of battle. But the submarine's imperfect vision occasions danger of interfering with friends when large submarine forces are concentrated for simultaneous concerted action, such as does not occur in the assemblage of any type of surface craft. Thus the submarine is not only an arm to be used by stealth, but its most favorable opportunities occur in dispersed and solitary action rather than in concentrated and co-ordinated action.

Having thus glanced at the offensive and defensive capabilities of submarines, we may now turn to the means of parrying their attack and of overcoming it.

Until the outbreak of the current great war there seemed to be no adequate defense against submarine attack, but necessity is the mother of invention in tactics as well as in material, and there is less to fear from the submarine now than at the outbreak of the war. The great ships which the submarine would most gladly meet find their best protection in rapid motion; for the slow submarine, seeing imperfectly, is disconcerted by swift movement, more especially if thus accompanied by frequent alterations in direction. But ships cannot be always on the move and it is necessary to provide both passive defense and active counter-attack against submarines. For harbors and certain sea areas the passive defense is furnished by wire nets, whose meshes are of a size suitable for catching submarines, while the counter-attack is made by thousands of swift patrol boats whose business is to destroy the submarine or force him down again whenever he comes to the surface for information or for air to start his engines and to recharge his batteries.

The success of these measures against submarines is undeniable. At the beginning of the war Germany's good fortune with submarines promised the most important results, but as the war drew on the efficacy of submarine warfare diminished as methods of reply to it developed. It is now an important arm, but not the supreme one. By a line of *a priori* reasoning the general broad conclusion to be drawn from this survey is that the submarine is essentially a defensive arm, whose use as an offensive arm, although practicable, yet partakes somewhat of the nature of a *tour de force*.

After this brief review of the general qualities of submarines and the probabilities open to them, we are ready to take up the consideration of the particular types of submarines best suited for American use. Preliminary to this examination it will be desirable to summarize the accomplishments of the submarine under the conditions imposed by the relative situations of the present belligerents.

The early performances of German submarines caused them to stand very high in popular estimation, but they have not yet been able wholly to justify the expectations they first aroused. The efforts of Germany to wrest the control of the sea from the grasp of Great Britain and her Allies called for the exertion of the highest type of offensive war; but, as we have already seen, the submarine, in its essential nature, is the defensive weapon of the weak. It met with a temporary success, first in the North Sea and later in the Mediterranean, which in each case lasted only until the Entente Allies had time to prepare counter measures. At the opening of the war British ships advanced boldly to the German side of the North Sea and maneuvered there at slow speeds. The hostile submarines took advantage of their opportunity, and the British forces withdrew from the vicinity of the German coast. Great Britain then developed the net defense of her ports and of the cross-channel routes to France, as well as the counter-attack against hostile submarines and mine-layers by the patrol flotillas, of whose work such an excellent idea is given in Kipling's "Fringes of the Fleet." After six months of warfare the Germans began their submarine attack upon commerce. The strategic features of this phase of the war need our consideration.

German submarines were charged with the aggressive task of destroying commerce, but owing to their essentially defensive nature they were obliged to lie in wait in positions where shipping would come to them. The favorite area was that between the south of Ireland and the western entrance of the English Channel, since nearly all British foreign commerce naturally took that way. But as the Straits of Dover were protected by nettings the Germans were obliged to pass around the North of Scotland to reach their station, a distance of about 1200 miles. Once there, it was necessary to lie on station some days in order that the time at work might be in reasonable proportion to the time needed to make the trip and return. Thus, as a matter of logistic economy, the submarine employed on this service required a large radius of action, which entailed a considerable size—about 800 tons. Our attention has been particularly centered on these large craft because their deeds attracted most notice, but they are not the only ones employed. We have every reason to believe that, where submarines are needed for their proper defensive rôle to protect the German coasts, much smaller ones are used. Similarly, the English—who have the mastery of the sea, yet need submarines to aid in the protection of their ports against sudden raids—make use of small ones. So far as we know, submarines have accomplished little or nothing during the current war when acting in company with the main fleets. At the Battle of Jutland last May they seem to have been absent or ineffective.

The evidence of the present war as to submarines may be summarized by saying that on both sides they have obtained a degree of success in defense, to the extent of forbidding the approach of the main fleets of both sides to hostile coasts. In this successful coast defense submarines have been greatly aided by mines.

The use of submarines for the purpose of strategic attack has been less successful, although Germany's attack, in particular, has arrested much attention. The submarine strategic attack has been chiefly directed against commerce, by the British and Russians in the Baltic Sea against German trade with Sweden, and by the Germans at the entrance to the English Channel against the ocean trade of France and Great Britain. While this destruction of commerce has been serious, it has not led to conclusive results, although the narrow waters in which this contest has taken place have been favorable to the efforts of submarines because commerce has been obliged to cross the areas infested by them.

In estimating the value of submarines in the current war we must not attribute the present shortage of commercial shipping wholly to the deeds of submarines. In the order of their importance the factors in this shortage seem to be:—First, the great military and naval demands made upon commercial shipping; second, the internment at home or abroad of all or nearly all shipping of the Central Powers; third, the delays imposed upon Allied shipping by the patrol and mine-sweeping services, which have adopted a retardatory but necessary administrative system for the protection of ships passing through dangerous areas; fourth, the actual loss of shipping caused by submarines, which seems to have been about 3 per cent a year, more or less, nearly the same the English merchant service encountered without serious consequences in the Napoleonic wars.

The foregoing discussion has had the objective of placing us in a position to consider what type of submarine will best suit the requirements of our own navy, and this we shall now proceed to do.

The geographic situation of the United States, with a very extended coast-line, much of which is remote from possible enemies and borders great oceans, is very different from that of the present combatants, who are separated by comparatively narrow waters and confront each other at relatively short ranges. As we have seen, the submarine is essentially a defensive arm. It finds least opportunity when it meets its enemy in the open sea with full freedom for maneuver. On the contrary, the submarine is favored when its enemy approaches a hostile shore, where his freedom of maneuver is hampered by the proximity of the coast and his advantage of speed is thereby partially counterbalanced. Therefore it does not seem desirable that our navy should attempt to establish a defensive cordon of submarines far from our coasts in mid-ocean. For a line held there will be long; its distance from shore will require much time to arrive at and return from station, necessitating excessive numbers of ships. The enemy has no objective in mid-ocean and will not wait there. If he is attacked in that neighborhood by submarines, he has the advantage of full opportunity to maneuver freely at high speed. On the other hand, our submarines will gain on every one of the above-mentioned points if they are used for local coast defense and do not go far off shore—say, not more than a day's run. They may well expect to maintain a strip of coastal waters fairly free from the enemy and available for coast navigation, as do the English at the present time. Thus the size and type of coast-defense submarine of about 500 tons now favored by our Navy Department seems the proper and logical one for American use. It is true that it is a much larger type of submarine which has obtained most Press notice in the current war, but that is because the requirements of the situation were such that the areas best suited to the operations of German submarines were far from German bases. We do not foresee any strategic reasons that will require our submarines to operate so far from home. American coast defense does not appear to require the largest type of submarines. Nevertheless, the Appropriation Act of this year calls for three of a large size (800 tons), which will prove instructive and useful as experimental boats even if they prove to be larger and more expensive than necessary. There is a great desire on the part of every navy to provide submarines capable of accompanying the fleet and taking part in general actions. For such a purpose a second type of submarine is necessary.

Such a craft will be away from its base for a longer time than coast-defense submarines, and must, therefore, have a larger crew and better quarters. Tactically, also, its requirements must be quite different. As was earlier pointed out in this paper, an automobile torpedo has a greater virtual range when it is fired to meet an approaching target than when it is fired to overtake a retreating target. Consequently an ideal torpedoboat, whether of the surface type or of the submarine type, should have superior speed to that of its probable opponent in order that, however the latter turns, the torpedoboat may assume an advantageous position ahead of the enemy before closing to discharge the torpedo. But this is a difficult condition to satisfy with a fleet submarine. The standard speed of battleships reached 21 knots some years ago, and is now on the rise once more. At present 23 knots may be regarded as the normal speed for foreign battleships of the most recent design, and our navy should not lag behind others in this respect. An ideal fleet submarine should have both surface and submerged speeds not less than 25 knots, and a submerged radius of at least two hours at maximum speed. Unfortunately, we cannot get a quart into a pint pot, nor is such an ideal fleet submarine practicable. No submarine even of as large size as 1200 or 1500 tons, can get sufficiently powerful machinery into her; first, because her hull weight must be great to withstand submergence, and, second, because she must be provided with two heavy systems of motive power, in place of one lighter one, such as surface craft have.

In the present state of engineering we shall therefore be obliged to content ourselves with a surface speed approaching the cruising speed of the fleet under war conditions, or about 20 knots. The submerged speed and radius must be very moderate; sufficient only to serve as a means of passive defense by concealment, but not enough for aggressive maneuvering while submerged. The mechanical limitations thus imposed upon fleet submarines restrict very greatly the tactical freedom of the commander-in-chief who attempts to utilize submarines in a general engagement. Other component elements of the fleet are all capable of acting in mutual support of each other in aggressive attack upon the enemy. The fleet submarine, limited as it is in speed, is incapable of such co-operative attack with other types, for it cannot force itself into the fight. The commander who seriously relies upon his fleet submarines in a general action must place himself upon the strategic defensive and so restrict his freedom of maneuver as to make it a chief objective to draw the enemy within the pre-established area of the submarines. It is clear that such a limitation is a severe handicap. It is nevertheless desirable that our fleet should be accompanied by submarines for use when opportunity serves. Those now building are abreast of present possibilities, but should be improved and developed in succeeding years as engineering progress dictates. The chief distinguishing characteristics for them are high surface speed with adequate surface endurance and habitability. High submerged speed and great submerged radius are comparatively secondary affairs unless most radical improvements are brought about in the methods of submerged propulsion, so that high submerged mobility may be obtained without undue sacrifice of surface mobility.

The conclusion to be drawn from this study is that the Navy Department has made a judicious decision in the combination of military characteristics which it has embodied in its latest designs of submarines for service with the fleet as well as for coast defense.—*Engineering.*

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THE TESTING OF AUTOMOBILE MOTORS—METHODS FOLLOWED AND APPARATUS REQUIRED[1]

By Ferdinand Jehle[2]

Tests on prime movers may be divided into two classes:

1. Tests made for commercial purposes.
2. Tests made for research.

Commercial Tests

In the commercial tests we are interested merely in the power developed and in the cost, that is, we are interested only in the results obtained without any explanations or reasons therefor. As an example we might take an acceptance test of a steam turbine in which we test for the output and the quantity of steam used to develop one horse-power. If tests show that the apparatus is not up to specifications, the machine is possibly not accepted, but no investigation is made as to the cause of the failure.

Research Test

This class of tests includes a study of the performance and a further investigation to discover the reasons for such performance. This involves a study of the theories involved as well as their application. As an example of this kind of test we may consider the study of any prime mover—gas engine or steam engine—in which all of the thermal and mechanical efficiencies are determined.

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[1] The *Sibley Journal of Engineering.*
[2] Laboratory Engineer of the Automobile Club of America.

TEST OF AUTOMOBILE ENGINE

In applying the above classification to automobile engines, the commercial test becomes what is ordinarily known as the factory test. Every motor is put through some sort of test to see roughly whether or not it gives the desired output. And sometimes, although not frequently, a test is also made to determine the amount of gasoline consumption per brake horse-power hour. At times tests are also made to determine the maximum speed, the idling speeds, and the acceleration. In scientific or research tests additional data, to arrive at the cause or reason for the results obtained in the factory tests, must be obtained.

OUTLINE OF COMPLETE TEST OF AUTOMOBILE MOTORS

In making a complete test of an automobile motor the following determinations are necessary:

1. Speed.
2. Torque at different speeds (from which is calculated the brake horse-power at different speeds).
3. Fuel consumption.
4. Frictional losses.
5. Ignition (spark advance).
6. Carburetion (mixture ratio and the degree of vaporization).
7. Combustion (exhaust gas analysis).
8. Compression.
9. Volumetric efficiency.
10. Heat given to the cooling water.
11. Sensible heat given to the exhaust.
12. Other observations as might have a bearing on the particular kind of test made, such as temperature of the oil in crank case, temperature of the cylinder walls, etc.

APPARATUS REQUIRED AND METHODS OF TAKING OBSERVATIONS

The most important measurement, of course, is the measurement of power, which is the product of the torque and the speed.

1. *Speed*

The speed is rather easily determined by simply counting the number of revolutions of the engine shaft by means of a revolution counter and watch. A tachometer may be used to give a rough indication of the speed, but as a rule tachometers are not sufficiently accurate to be used for the purpose of the various calculations. Much time and care has been spent in the testing laboratory of the Automobile Club of America to perfect the revolution counting devices. These are constructed so that either one of two counters may be connected with the dynamometer or engine shaft at will. In making a long test it is especially necessary to have two separate counters. At the beginning of the test the zero reading of both is noted and at stated intervals during the test, say every 10 minutes, the one counter is released and the other connected to the shaft, thus giving a total count of revolutions and at the same time a breaking up of the total count into comparatively short intervals of time.

2. *Torque*

The problem of determining engine torque resolves itself into the problem of choosing a dynamometer that is suitable for the work. Before deciding what dynamometer is best suited for the testing of automobile motors, a careful study of the torque curves of such motors is necessary. In Fig. 1, *A* shows a characteristic torque curve of an automobile motor. By studying this curve it will be seen that as a rule there are at least two different speeds at which the engine develops the same number of pounds feet of torque and the question has often been asked the writer: Why is it that the motor can be held at say 900 r. p. m. and does not speed up to 1200 r. p. m., which has the same torque? The answer to this question, of course, is that the speed at which the motor will run is dependent upon the combined characteristics of the motor torque and the resistance of the dynamometer used to absorb power. To make this perfectly clear let us study the characteristics of the different dynamometers in general use and compare them with the characteristic torque curve of automobile motors.

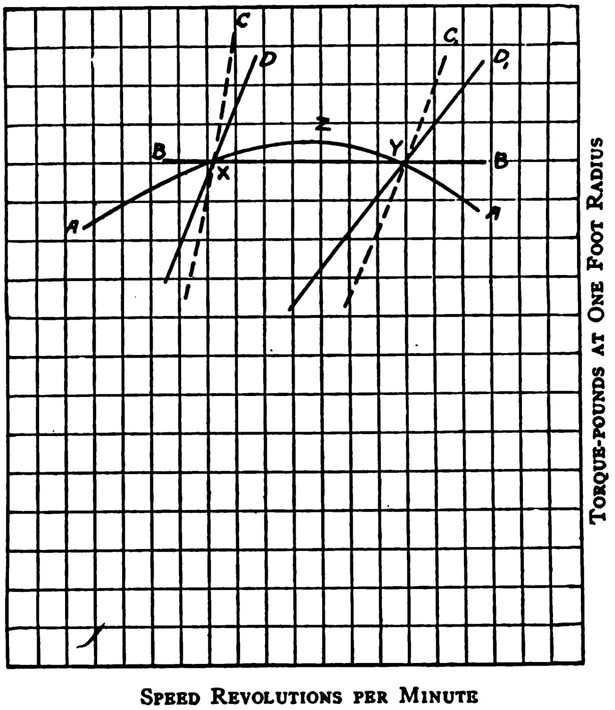

Fig. 1. 3030

Curves showing Characteristic Automobile Motor Torque Curves and Load Curves of Different Types of Dynamometers

Frictional Brakes

This type of brake includes all such dynamometers which use the friction of two surfaces for absorbing the power. Under this heading come the familiar prony brake, the rope brake, and the Alden brake. The characteristic of this brake, that is, the resistance with a given setting, practically does not depend upon the speed; in other words, the resistance curve for different speeds is practically a straight line for brakes of this description. In Fig. 1, *B* represents the characteristic curve of a frictional brake. It will be noted that the torque at points *X* and *Y* are identical. *B* represents the characteristic resistance of a frictional dynamometer set so as to absorb the load at the point *X*. It will be noted that at all speeds to the left of *X* the resistance is greater than the torque of the motor, consequently if the motor for any reason should slow up it would be stalled.

At all speeds between points *X* and *Y* the resistance is less than the torque developed by the motor, consequently the engine is at liberty to speed up, until point *Y* is reached. A further increase in speed would therefore be impossible because the resistance is greater than the torque developed by the motor. By studying these curves it can be seen that the motor operation would be stable at point *Y*, but not at point *X*, and if it were desired to run at point *X* it would be necessary to station a man at the adjustment of the prony brake so that he could increase the load slightly every time the motor speeded up and release it every time it showed a tendency to slow down. This would be necessary in trying to operate the motor at any speed below the speed of the maximum torque, which in the illustration in Fig. 1 is point *Z*. The operation at speeds above point *Z* would be stable. This class of dynamometers is therefore not adaptable to the testing of ungoverned automobile motors. The curve *B* in Fig. 1 must not be considered as representing absolutely the power-absorbing characteristics of a friction brake. This, of course, depends entirely upon the coefficient of friction, which does vary with the speed, but not a very great deal.

Dynamometers Depending Upon the Resistance of a Fluid

This class includes water dynamometers and fan dynamometers. For a given setting of a water dynamometer and for a fan dynamometer with a certain set of blades at a given distance from the center, the resistance varies approximately as the square of the speed. In Fig. 1, curve *C* and C_1 represents the characteristics of such a dynamometer. Curve *C* is for the dynamometer set to hold the motor at speed *X*. The one at C_1 is to hold it at speed *Y*. By comparing the curves *C* and *A* it can at once be seen that the motor cannot increase its speed, due to the fact that the reresistance increases much more rapidly with the speed than does the motor torque. If for any reason the speed is reduced the motor cannot be stalled because the resistance falls off more rapidly than the torque of the motor. A dynamometer of this description, therefore, has load characteristics which are ideal for testing automobile motors. Both water dynamometers and fan dynamometers, however, have other characteristics which make them undesirable for this purpose. In the fan dynamometer there is no way of measuring the power except by calibrating the fan and this is a very difficult thing to do, inasmuch as the power absorbed by the fan at a given speed depends upon the barometric pressure, the temperature, of the air, and above all, its surroundings. If a fan is operated in close proximity of a wall or some other object, the power taken to drive it at a certain speed is much less than if it is further removed from surroundings. Air currents also greatly affect it. Then, there is the inconvenience of having to change the size of blades or varying their distances from the center to change the load and speed of the motor. The water brake, on the other hand, can be mounted so that its torque reaction can be measured upon a balance and the load can be quite easily controlled. It has the disadvantage, however, that its maximum absorbing power varies roughly as the cube of its speed and consequently a brake that would absorb the power of an automobile engine at all speeds ranging from a few hundred r. p. m. to 3000 or over r. p. m., would hardly be possible. If the brake were designed to meet the requirements at low speed, it would have to be of very large proportions, in fact, the rotor would have to be so large that the minimum load at high speed might be beyond the power developed by the engine under test. If, on the other hand, the dynamometer were designed to meet the requirements at high speed, the rotor would not be large enough to absorb the power at the lower speeds.

Electric Cradle Dynamometers

This type of dynamometer is most desirable for the testing of automobile motors and has been practically universally adopted for the purpose. In Fig. 1, curve D and D_1 represents the characteristic resistance curve of a dynamometer of this description. At D the load has been set to hold the engine at speed X, while D_1 is set to keep the speed of the engine at Y. The torque varies directly as the speed. It can be seen from the curve that the load therefore will increase more rapidly than the torque of the engine and also falls off more rapidly than the engine torque. For this reason the engine cannot hunt, but is held at a constant speed. Its characteristics in this respect are equally as good as those of the fan or water dynamometers. In other respects it is much more desirable, however, than either the fan or water dynamometer for the testing of automobile motors. These advantages are chiefly that it has practically during its entire speed range a constant torque. This refers, of course, to the maximum torque that can be obtained at the different speeds. This torque, or resistance, is dependent upon the current capacity of the machine. The power which the dynamometer can absorb varies directly as the speed up to the point where the maximum permissible voltage is reached and from that point on to the maximum speed the power absorbing ability is constant. Another great advantage is that the load is very easily controlled. This is accomplished either by varying the armature resistance or by varying the field strength. In making a test of a motor on an electric dynamometer it is best to so adjust the armature resistance that the dynamometer will absorb the power at the lowest motor speed. At the other speeds the load can be adjusted by manipulating the field rheostat.

Another advantage of the electric cradle type of dynamometer is that it can be used to run the engine and thus the friction losses of the motor under test can be determined.

The high speed dynamometer in the testing laboratory of The Automobile Club of America is capable of handling somewhat over 100 horsepower continuously from 1500 r. p. m. to its speed limit, which is above 3000 r. p. m. A heavier duty machine in the same laboratory has a continuous capacity of approximately 120 horse-power at as low a speed as 1000 r. p. m. Its maximum speed is 2000 r. p. m. This testing equipment is especially arranged to accommodate aviation motors, inasmuch as the bedplate upon which the motor is erected is enclosed in a sheet-metal house and a current of air of approximately 40 to 50 miles per hour is blown past the motor under test. This imposes upon the motor practically operating conditions. For higher powered motors than 120 horse-power, both the dynamometers are coupled together. The continuous capacity is then about 200 horse-power.

3. *Fuel Consumption*

The fuel consumption can best be determined by placing the tank which contains the fuel supply for the motor upon a scale and noticing the decrease in weight. In tests of very short duration in which very small quantities of fuel are consumed, it is preferable to determine the consumption volumetrically, that is, to measure in a pipette the quantity of fuel consumed.

4. *Frictional Losses*

It is not possible to obtain a reliable indicator diagram from automobile motors, chiefly due to the fact that there is no instrument made that will operate successfully at the high speed that motors are operated at. There are on the market several optical indicators which are designed to draw indicator diagrams at these high speeds, but as yet they have not been absolutely successful. For this reason it is not possible to determine the frictional losses by comparing the indicated horse-power with the brake horse-power. As noted above, however, with the electric cradle dynamometer it is perfectly possible to determine the friction losses at the different speeds. If it is desired to obtain the indicated horse-power for use in expressing the thermal efficiency, this friction horse-power at a given speed can be added to the brake horse-power developed at that same speed. It is quite true that the friction determined when the engine is not operating under its own power may be slightly different from the friction when the engine is operating under its own power. Nevertheless, the error introduced is less than would be introduced if an indicator diagram were to be used for this purpose.

5. *Ignition*

The spark advance, that is, the number of degrees of crank-shaft travel that the spark takes place in the cylinder before the piston arrives at top center, is of great importance. The apparatus in use for determining this in the testing laboratory of The Automobile Club of America consists of a pointer rotating in front of a protractor which is insulated from it. The gap between the pointer and protractor is connected in series with the high tension side of the ignition system, and when the spark occurs in the cylinder it will also jump the gap mentioned and the number of the degrees can be read on the protractor at which this takes place. Needless to say, the pointer is revolved at the same speed as the crank shaft of the engine and is set on zero when one of the pistons is on top-center.

6. *Carburetion*

It is of great importance to learn what the ratio is of the air supplied to the motor to the gasoline used. The method used in determining the quantity of gasoline consumed has already been described. It is now necessary to measure the air consumed. There are various ways of doing this, the most accurate of which, of course, would be to use a gasometer. It would, however, be very expensive to install a gasometer of such capacity to run a motor for any length of time and we must therefore look for more practical means to make this measurement. The best method for this purpose, in the writer's estimation, is to make use of a Venturi meter which has been calibrated by means of a gasometer, although it would be quite possible to use a standard orifice. Another investigation that is of importance is the amount of vaporization that takes place before the mixture enters the cylinders. Some idea of this can be obtained by comparing the temperature of the ingoing air with the temperature of the mixture in the manifold.

7. *Combustion*

It is as necessary to study the combustion which occurs in the cylinders of an automobile engine as it is to study the combustion under a steam boiler in making a boiler test. The only way of accomplishing this is to make an analysis of the exhaust gases. It is desirable that the CO content of these gases be kept at quite a low figure, although, strange to say, the maximum power is not obtained when there is no carbon monoxide present, but when there is approximately 4 per cent. Maximum economy, of course, does not occur at this same point. From the percentage of CO present the heat lost, due to incomplete combustion, can be determined.

8. *Compression*

The amount of compression in the cylinders is dependent upon several things. First, the size of the valves; second, the valve timing; third, leakage around the piston rings. The method which the writer has found to be most satisfactory for measuring this pressure is to use a steam gauge connected to an expansion chamber, which is in turn connected to the engine cylinder by means of a check valve. There is another instrument on the market, the O'Kill indicator, which gives fairly good results. This instrument, however, is quite difficult to calibrate.

9. *Volumetric Efficiency*

The volumetric efficiency is the ratio of the air taken into the motor in a given time to the effective piston displacement during the same time under existing atmospheric conditions. The air measurement to determine the mixture ratio described above can, of course, be used for this calculation.

10. *Heat Given to the Cooling Water*

To determine this loss it is necessary to measure the difference between the ingoing and outgoing cooling water and the quantity of water circulated per unit of time. The temperatures, of course, are easily measured with mercurial thermometers, while the quantity of cooling water circulated can either be weighed on a scale or measured with a calibrated meter. In the testing laboratory of The Automobile Club of America a calibrated Venturi meter is used for this purpose.

11. *Heat Lost in the Exhaust*

The heat lost in the exhaust can best be determined by cooling the exhaust to room temperature by means of water in a calorimeter and measuring the increase in the temperature of the water and the quantity of water used. The calorimeter in use in the testing laboratory of The Automobile Club of America for this purpose consists of a steel barrel enclosed in a wooden box. The space between the barrel and the box is filled with wood shavings which makes a very good insulator. The piping from the exhaust manifold to the calorimeter is insulated, as well as the exhaust manifold. The cooling water is injected into the exhaust pipe and follows the exhaust into the calorimeter. The exhaust gas can escape by bubbling through the water. The temperature of the exhaust gases as they leave the calorimeter is the same as the temperature of the air entering the carbureter.

12. *Other Observations*

Other measurements that are at times necessary are the temperature of the oil in the crank case, which can be determined by drilling thermometer wells into the crank case and reading the temperature on mercurial thermometers; the temperature of the exhaust, which can be determined by pyrometers; the temperature of cylinder walls, etc.

The design and construction of apparatus necessary to make determinations and measurements on tests, is one of the important duties of the testing engineer. Nevertheless, he must not lose track of the fact that this is merely a means toward an end and the complicating and increasing expense of apparatus is never justified unless it will help and make more valuable the data or the results obtained. Too often apparatus builders and engineers in charge of laboratories unnecessarily increase the expense and complications of apparatus. Automatic apparatus may be desirable for factory tests where the class of labor employed for making the tests is below that in the scientific laboratory. The best method to follow is to use absolutely the simplest apparatus which will meet the various requirements.—*Scientific American Supplement.*

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MACHINE-GUN RANGE-TABLE FOR FLYING TARGETS

By First Lieutenant G. P. Wilhelm, 4th U. S. Infantry

Modeled after the table of machine-gun fire given in the article "New Methods of Machine-Gun Fire," printed in the October-November issue of the *Infantry Journal,* the table on p. [264] has been calculated for the Benet-Mercier machine gun.

This table, which is typewritten, with the headings in black ink and the figures in red ink, is pasted on a sheet of flexible transparent celluloid. The sheet of celluloid is then attached to the reverse side of a sketching board where it is out of the way when the board is used for sketching.

The sketching board is also made for use as a slope board with string and lead plummet on the back of the board in a groove that has been chiseled out for the purpose. The sketching board and folding tripod are carried in a canvas case, packed as a top load on a pack mule. This makes it possible to have always a sketching outfit with the company as well as a table and angle reading instrument for aeroplane fire.

The procedure of using this table is as follows:

Upon sighting an aeroplane, the Range Finder (Baush and Lomb, 80-cm.) immediately begins to get the range. At the same time, by sighting over the surface of the slope board, the angle to the aeroplane is easily obtained. This sighting may be made more accurate by setting a screw eye of small diameter in the board near where the eye will sight and, at the other end, a brad. The screw eye serves as a peep sight while the brad acts as a front sight.

After obtaining the range and the angle, the table immediately gives the correct sight setting (with due allowance for 300 yards searching fire); the proper amount to turn the handwheel for 300 yards searching fire, and the necessary distance to aim in advance of the aeroplane. This distance is given in mils and may be obtained by using any form of mil stick; by holding the eye above the elevating mechanism, which makes the rear-sight leaf subtend approximately 100 mils—half of the sight leaf is of course 50 mils; or by using the finger system and calling one finger 50 mils. The aiming point once found approximately, this distance is fixed in the mind as a point in the air or against a cloud at the measured distance in front of the aeroplane.

RANGE-TABLE FOR MACHINE GUNS FOR USE AGAINST FLYING TARGETS.[1]
300 YARDS SEARCHING FIRE AND FIRE OF 5 GUNS SIMULTANEOUSLY IS NECESSARY

Range in yards obtained by Bausch and Lomb range finder, and elevations by slope board						Turns of hand wheel down in order to get 300 yds. searching fire	Aim to be taken in mils in front of target
					(1)	(2)	(3)
8°	40°	50°	60°	70°	80°		
800	1000	950	900	850	800	3/16	60
900	1100	1000	1000	950	850	1/4	60
1000	1200	1150	1050	1000	900	1/3	65
1100	1250	1200	1100	1050	900	3/8	65
1200	1300	1250	1150	1050	950	7/16	70
1300	1400	1350	1250	1100	1000	1/2	70
1400	1475	1400	1350	1175	1000	1/2	70
1500	1550	1500	1400	1250	1050	9/16	80
1600	1600	1550	1450	1300	1100	5/8	80
2000	1800	1700	1550	1400	1200	3/4	85

(1) Angles measured by bullet, string, and slope board. Tables pasted on board.
(2) Benet-Mercier.
(3) Calculations based on 80 miles per hour.

The table which has actually been constructed and carried on a pack mule in the machine-gun company, 4th Infantry, has never been tried out, nor are the calculations vouched for. It is asserted, however, that by use of this table the chance of bringing down an aeroplane is at least as good or better than by trusting entirely to luck and guess work.

—*Infantry Journal.*

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[1] Above table is not appropriate for flying targets heading directly toward the firing point. In that case, distributed fire, 50 mils on each side of target must be used.

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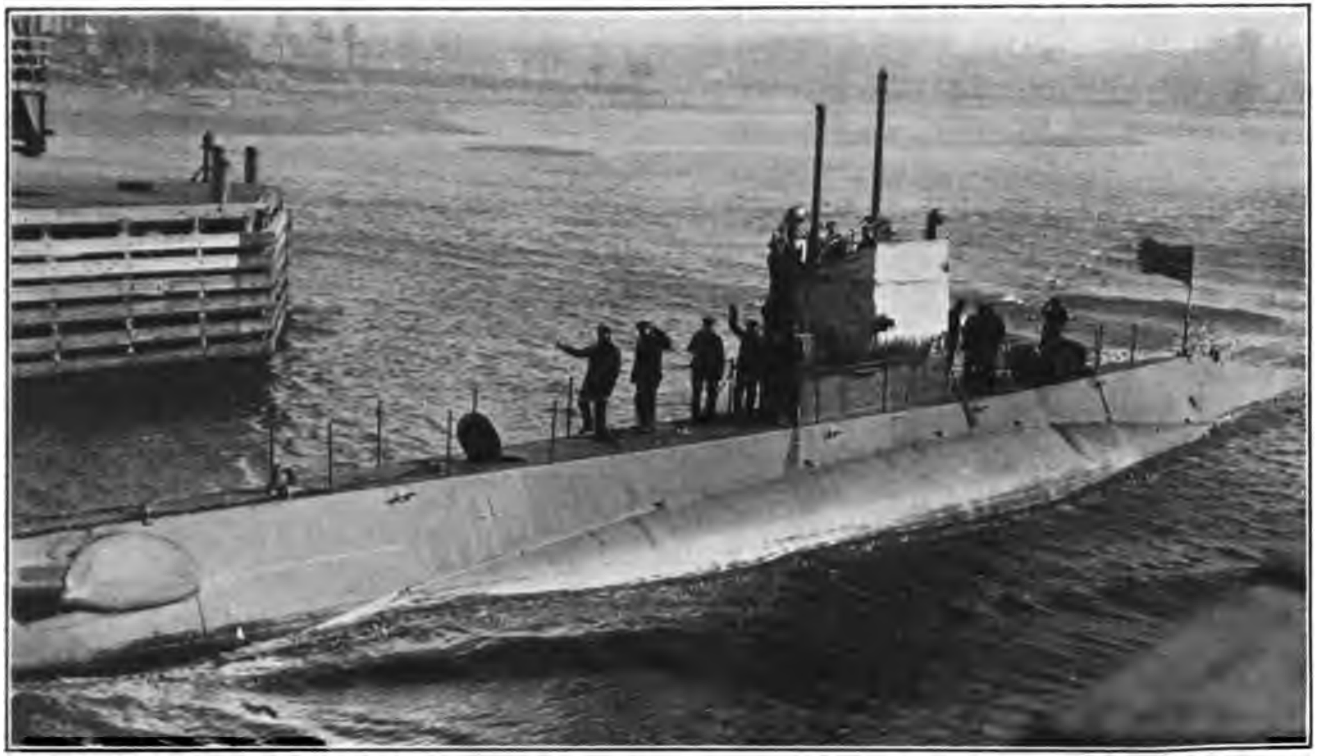

Photograph by Boston Photo News Company.

2021

THE U. S. SUBMARINE L-1

NAVAL NOTES[1]

GERMAN SUBMARINES FROM A BRITISH VIEWPOINT

Some curiosity has naturally been exhibited as to the engines of the newer German submarines. In the course of an article on this subject *The Shipbuilder* points out that the Germans owe the measure of success which their submarines have attained, in the main, to the successful development of the Diesel engine. At a time when many engineers in this country were inclined to sniff at this type of motor engine, the Germans, with characteristic energy, devoted themselves to its development, and before the outbreak of war it was known that they had met with the reward for which they had worked. The German naval authorities adopted the very sensible course of sending officers and men to "grow up" with the engines, thus enabling them to acquire that knowledge of material so essential to the efficient and reliable operation of light, high-speed reciprocating machinery. The great majority of Germany's submarine engines are manufactured at Augsberg and Nuremberg, and by Krupp at Kiel. The Augsberg engine was of the four-cycle, single-acting type, directly reversible by compressed air, and was built to develop 1000 b. h. p. in six cylinders at 450 r. p. m. The cylinder bore was 310 mm. and the stroke 420 mm. Just before the declaration of war the Nuremberg works had under construction or test a number of eight-cylinder, single-acting, two-cycle submarine engines, rated at 850 b. h. p. at 450 r. p. m., but powers as high as 1050 b. h. p. could be obtained when necessary. This type of engine had a cylinder bore of 310 mm., a scavenger-cylinder bore of 475 mm., and a stroke of 340 mm. The Krupp two-cycle engine, as built just prior to the declaration of war, was a six-cylinder, single-acting engine, directly reversible by compressed air, and developed about 900 b. h. p. at 450 r. p. m. At higher speeds of revolution about 950 b. h. p. was obtained. It may be that the power of the Augsberg four-cycle and the Krupp two-cycle motors has been increased by adding two more working cylinders, thus making each type capable of developing about 1350 b. h. p. In the case of the Krupp design, however, the engine would be excessively long. At any rate, the Germans have evidently made the Diesel engine a conspicuous success.—*Naval and Military Record* (British).

EIGHTEEN-INCH NAVAL GUNS FOR USE ON LAND

The British are building a naval gun of 18-inch caliber, weighing from 150 to 160 tons, firing a high explosive projectile that weighs 2950 pounds, and with an armor piercing power which exceeds anything heretofore known in ordnance. It is the biggest and most destructive weapon of warfare yet devised.

In naval circles here, where the report about the 18-inch gun has just been received, the opinion is expressed that it is intended for operations against land fortifications. In view of the achievements of big guns at Liege, Namur, and Antwerp, it is believed that the new monster gun is being prepared for the great advance.

Such a gun, it is said, is too big to be of practical value in naval warfare. It would require an increase in the tonnage of the *Pennsylvania*, a 32,000-ton vessel, to mount six of these giant guns. The *Pennsylvania* carries twelve 14-inch guns, which have an armor piercing range of about 16,000 yards. And, in the opinion of ordnance experts of the Navy Department, the reduction in the number of guns from twelve to six, which the mounting of the 18-inch type would necessitate would force a reduction in volume of fire and in the destructive area of fire that the greater armor piercing range and the higher destructive powers of the 18-inch projectile would not countervail.

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[1] From *Proceedings U. S. Naval Institute.*

But the reports regarding the 18-inch gun are of such character that credence is given to them by naval officers and the belief is that the British propose to spring some new sensation in attack upon land fortifications. In that case, it is said, these guns would be mounted on moving fortresses, probably with a specially constructed turret of greater height which would permit a higher angle of fire and consequently a greater range.—*New York Herald.*

Notices

A sample tube of B. S. A. "Safetipaste" received some time ago from the Birmingham Small Arms Company, Limited, was tested by one of the companies at Fort Monroe, Virginia, according to the program and with the results given below:

February 1, 1917.—A minor field firing problem was attempted in which 10 rifles were used, and ten shots per rifle. About one-half an hour after the completion of the firing, and without any other attention, the B. S. A. paste was applied in the bores.

February 2.—One rifle was cleaned with dry rags and was readily cleaned and found bright. It was replaced in the store-room for further inspection, without oiling.

February 3.—Second rifle was cleaned as before and found bright. The first rifle was also inspected and found bright.

February 6.—Third rifle was cleaned as before and found bright. The first and second rifles were found bright.

February 8.—Fourth and fifth rifles were cleaned as before and found bright. First three rifles were found bright.

February 12.—All the remaining rifles were cleaned as before and found bright. The first five rifles were inspected and found clean and bright. As before, all the rifles were replaced in the store-room without oiling.

February 21.—All the rifles had remained bright until this date. The only attention they had received was cleaning out of the paste with dry rags, and this was readily accomplished in each case. The test being discontinued, all rifles were oiled and polished somewhat thereby, and replaced in the store-room.

It is believed that this paste is a valuable composition. That it contains no harmful ingredients is shown by the fact that no corrosion occurred after the paste had been removed by dry rags. While this test is limited, it is believed that it clearly indicates a substantiation of the claims of the manufacturers.

The JOURNAL U. S. ARTILLERY desires to receive from its readers, titles of subjects which they consider would be of interest to the service. A title will be published (either on the "Prize Essay" announcement page, or immediately following "Short Notes") until a paper on that subject has been received.

BOOK REVIEWS

Coast Artillery Matériel. Second Edition, Revised. By Captain W. P. Platt, C. A. C. Kansas City, Mo.: Franklin Hudson Publishing Company. 5¼" x 7". 178 pp. 14 il. 1917. Price, $0.60.

The second edition of Captain W. P. Platt's *Coast Artillery Matériel* has been recently issued. It now has additional data on searchlights, and all changes have been made in the book necessary to make it comply with the annual instruction order for Coast Artillery for 1917. A few corrections have been made to the text of the first edition.

The book is the result of the practical experience of Captain Platt as Instructor-Inspector of the California Coast Artillery. He found that it was necessary, if real professional progress was to be made by Coast Artillery Militia officers and men, that they be given, under the covers of one book, a great deal of material with which it was important that they should be familiar and which they could otherwise acquire only by consulting a great number of books and pamphlets. In this respect the book is fully up to the expectations of its author.

In the course of his experience as Instructor-Inspector Captain Platt learned that militia officers needed to be told not only what to do but that they could more intelligently absorb and retain such directions if they were told the reasons for them. *Coast Artillery Matériel,* therefore, not only contains a great deal of otherwise practically inaccessible information, but the text is a running comment, giving the practical reasons for many of the rules. And where a knowledge of physical laws will be illuminating, a terse explanation of their principles and operation has been given. In these respects this book materially differs from the usual books and pamphlets upon the service of Coast Artillery.

The book contains the following chapters: 1, Organization and Coast Defense; 2, Gunnery and Ballistics; 3, Ammunition; 4, Guns and Carriages; 5, Fire Control Apparatus; 6, Drills and Inspections; 7, Searchlights and Signaling; 8, Commands; 9, Cordage; 10, Warships; 11, Target Practice.

In addition the book contains a list of questions asked in the various Militia Bureau examinations for officers and for rated position men to and including those used in the November, 1916, examinations. With all these questions are given back references to the text of the book, where the subjects are discussed to which the questions refer. This feature of the work will prove of very great assistance to the officer or man preparing himself for examination. The book in addition contains a series of questions referring to every paragraph of every chapter of the Drill Regulations for Coast Artillery, which are very useful for self-quizzing. An excellent index completes the book.

While primarily designed for the use of Militia Coast Artillery officers and men and recommended for their use by the Militia Bureau of the War Department, the author very properly is of the opinion that it will be found useful to the junior officers and enlisted men of the regular service.

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Lessons in Visual Signaling. By Second Lieutenant M. A. Palen, U. S. Inf. Menasha, Wisconsin: Geo. Banta Publishing Co. 4½"x5½". 30 il. 60 pp. 1916. Cloth. Price, $0.60.

The object of this book as stated by the author is not to present a treatise on visual signaling but to furnish a system for training men in the use of the flag kit provided by the Signal Corps.

It consists of ten lessons in wig wag signaling and eight lessons in two arm semaphore work.

In each lesson in wig wag are given the signals for a few letters and then words made from those letters and the letters of the previous lessons.

In this way the instruction is progressive and never beyond the capacity of the average man.

A similar method is followed in the semaphore instruction with the addition of showing pictures of the different positions.

The book is well printed and well bound and it is believed that the system described would be of great assistance to company commanders.

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The South American Wars of Independence. By Gerald Ellis Cronin, First Lieutenant, 9th U. S. Infantry. A monograph printed by A. E. Vidaurri Sons, Laredo, Texas. 6¼" x 9". 20 pp. Paper.

It is remarkable how little our Country knows of the domestic history of the South American States, and no line of study would tend more to increase happy affiliations between ourselves and our southern neighbors than an interested inquiry into the history of their struggles for independence.

In a short monograph recently prepared by Lieutenant Cronin of the Infantry, he presents in a few pages a summary of the South American Wars of Independence which offers a starting point from which those interested may extend their reading indefinitely. As the author states: "Comparatively few works have been written in this country on the wars of our fellow Americans with whom our commercial and perhaps our military relations are destined to become closer as time rolls on."

The article deals, first, with the revolutionary movement in the northern sector of South America—Venezuela, Columbia, and Ecuador—wherein the adventurer Miranda and the patriot Simon Bolivar fought and schemed to overthrow the power of Spain. Then the spirit of unrest which spread westward from the Rio de la Plata, through the Argentine into Chile and Peru, under the able direction of San Martin, is briefly discussed; and finally, the events which transpired in Bolivia and Peru, where the northern and southern movements united, and the freedom of South America finally assured by the success of Sucre at Ayacucho, December 9, 1824.

The independence of the Portuguese colony of Brazil forms a separate chapter in the history of South America. The creation of the Kingdom of Brazil in 1815 as a part of Portugal, and its later declaration as an independent Empire under Dom Pedro in 1822, are briefly referred to.

It is impossible to acquire in a few minutes reading a sympathetic and comprehensive picture of the history of the South American States covering the period 1806-1822, for the terseness of condensation is so considerable as to produce a kaleidoscopic effect rather intricate, and quite difficult to decipher. The inquiring reader is given occasional glimpses of the heroic work done by the "*Liberator*," and the brilliant strategy of San Martin in attacking the Spanish power in Peru—not by the inland route through Bolivia, but by way of the seemingly impassable Andes to Santiago and thence to Valparaiso.

The monograph might well have been made longer and its value thereby greatly increased.

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The Swiss Army System. By Captain Remy Faesch, 22nd Infantry Regiment of the Swiss Army. New York City: G. E. Stechert & Co., 151 W. 25th St. 5″ x 7¾″. 24 pp. 21 il. Paper. Price, $0.25 single copy; discount on lot deliveries.

This little pamphlet, with its twenty-one interesting half-tones, sets forth in a concise way the history of the present military system of Switzerland and leaves the reader to draw his own conclusions as to its applicability to American needs and American institutions.

A sharply condensed history of the Swiss Confederation, followed by an outline of the discipline and demands laid upon the individual by the state, brings out clearly the fact that in this sturdy little republic every male citizen must in some capacity bear his certain proportion of the defense burden.

It is seriously to be doubted if such a system, built up as a result of centuries of experience with practically fixed conditions and a permanent population could be made to meet the needs of the United States and her possessions, yet some valuable features may be drawn from it and it merits careful study.

Details and statistics are lacking, but a perusal of this little book will give anyone a fair working knowledge of the Swiss system, and bring home with new force a realization of the vital defects in our own.

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Journal of the United States Artillery

May-June 1917

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JOURNAL UNITED STATES ARTILLERY

PRIZE ESSAY COMPETITION

1917

The JOURNAL U. S. ARTILLERY announces the following for its annual competition.

PRIZES

One hundred and fifty dollars will be given for the best essay and one hundred dollars for the second best essay submitted on any coast defense subjects.

CONDITIONS OF THE COMPETITION

(a) Competition will be open to all readers of the JOURNAL.

(b) Award will be made by a committee of award, consisting of three persons, to be nominated by the Coast Artillery School Board. If no essay submitted seems to the committee worthy of a prize, none will be awarded. Honorable mention may be made of any essay submitted which seems to the committee worthy thereof, but to which a prize is not awarded.

(c) All essays entered in competition will become the property of the JOURNAL OF THE UNITED STATES ARTILLERY. These will be published, if approved by the Coast Artillery School Board.

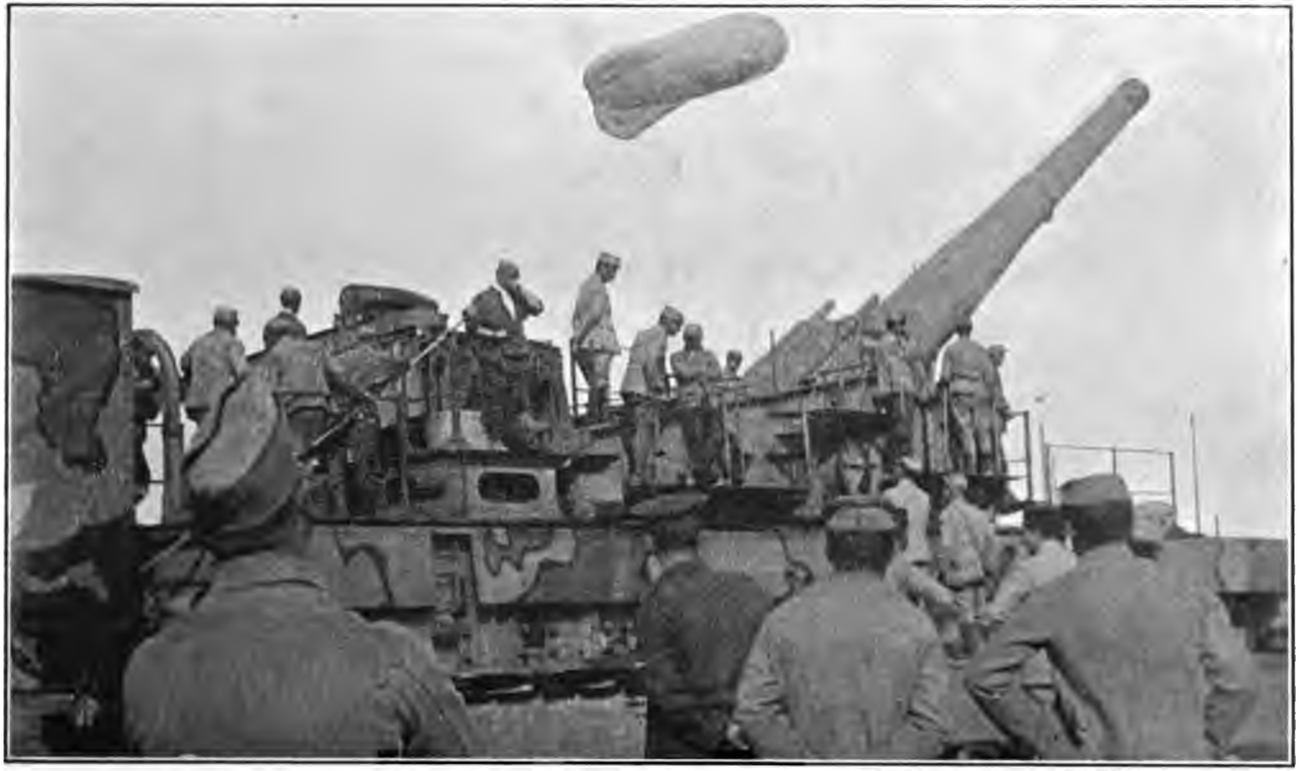
(d) Copy must be typewritten, with lines double spaced, on one side of the paper only, and must be submitted in triplicate. If illustrations are included, one of the three copies thereof must be in the form of drawings, tracings, or photographs (not blue-prints nor brown-prints).

(e) Copy must contain nothing to indicate its authorship, must be signed with a *nom de plume*, and must be accompanied by a sealed envelope containing this *nom de plume* and the name of the writer. This envelope will remain in the hands of the Editor of the JOURNAL and, after award has been made by the Committee, will be opened in the presence of the Coast Artillery School Board.

(f) Copy must be received on, or before, December 31, 1917. It must be addressed JOURNAL U. S. ARTILLERY and the envelope must bear the notation, "Essay Competition."

NOTICE

The JOURNAL U. S. ARTILLERY desires to receive from its readers titles of subjects which they consider would be of interest to the service. A title will be published (either on the "Prize Essay" announcement page, or immediately following "Short Notes") until a paper on that subject has been received.



A French Rail-Road Gun and an Observation Balloon

JOURNAL
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Second Prize, Essay Competition of 1916

INITIAL STRATEGY ON OUR NORTH ATLANTIC FRONTIER—A STUDY IN THE PREPARATION OF WAR PLANS TO MEET CERTAIN CONDITIONS.

BY CAPTAIN HOWARD L. LANDERS, C. A. C., U. S. ARMY[1]

"PREPAREDNESS" AS A STUDY FOR OFFICERS OF THE ARMY

"Preparedness" is the slogan now ringing throughout the United States for a year and more. To some the subject is of but academic and impersonal interest. To the great majority of our people, however, the issue is vital above all things else in life. To the soldier "Preparedness" means his best professional efforts. It is his life work today as it was three years ago; only broader, more intense, more requisite to safeguard the welfare of the nation.

For ten years the army has been interested in the study of war as an art, the most intricate and important development of their professional capacity. The evolution of effort has been continuous but disjointed; the ends desired seemed impossible of attainment, and so difficult of accomplishment as to dull the ambition of many to engage in seemingly unproductive work. There is lack of co-ordination in our methods of instruction, and a failure to understand that the training of an officer for higher command should be on the broadest lines possible.

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[1] Now of the 7th Field Artillery, U. S. Army.

CRITICISM OF THE COURSES AT THE SERVICE SCHOOLS

At the Coast Artillery School professional subjects are taught in great detail, but the student body has its mind directed too little towards the great principles of national defense. Our first line of land defense consists of more than artillery matériel, for without the co-operation of mobile forces our seacoast defenses cannot endure. The coast artillery captain of today has the same right to be trained and prepared to fill the highest command that the infantry captain looks forward to.

At the Leavenworth schools similar deficiencies in the system of instruction are found. The academic body ignores the functions of the coast artillery personnel and matériel in the teachings on strategy, as applied to our eastern and western frontiers. The fault lies in the failure of the instructors to understand naval and land defense warfare. A strategical situation, involving the mobilization and concentration of armies on our Pacific coast, is sadly lacking in breadth of scope, if prepared solely on the hypothesis that the enemy has landed in force, and that sea control and possession of our coast defenses are in his hands. The only excuse for presenting a problem on which war plans are to be based, in such a light, is the fact that the mobile army is familiar neither with naval strategy nor the possibilities and limitations of our outer line of land defense. It is as a result of such defective instruction and training that some officers today consider that, were this country attacked on the Atlantic seaboard, all our land forces should be concentrated west of the Hudson, and the coast-line from New York to Portland abandoned to the enemy. In the last two years an effort has been made at Leavenworth to correct this provincial viewpoint so prevalent there, but satisfactory improvement cannot be hoped for until the plan is adopted of sending mobile army officers to Fort Monroe during the target practice season of the class for the purpose of familiarizing them with coast artillery methods and the strategy of naval-coast defense warfare.

At the Army War College the instruction in most of the problems tends to develop, modify, and amplify theoretical war plans; and as the student body is composed of selected officers of mature judgment, the results of their deliberations form the bases for tentatively constructed plans which are possible of development into definite structures. The course should be broadened, however, to include a more comprehensive knowledge of national policies, and the strategy of operations should be taught on maps reaching to Europe on the east, and to the Orient on the west. Time is spent now in work that properly pertains to the Staff College.

DEFENSE PLANS AND JOINT MANEUVERS AT COAST ARTILLERY FORTS

In reviewing the diversified work done in recent years by the Coast Artillery Corps we find that it has been quite extensive and progressive, and the time has now arrived when it can be made more profitable. Eight or ten years ago all seacoast posts took up the study of local defense plans, and the co-ordination between the coast defenses and the mobile army was pointed out in several monographs prepared by boards composed of officers competent to speak with authority. Plans were prepared based on the troops available; others on the troops which might be expected at the end of two or three months; and still others on the maximum forces desired. Calculations were made as to the time, men, matériel, and money necessary to construct huge embankments to cover stations of observation, buildings of vital importance, and batteries subject to land or sea attack from the flank or rear.

Artificial systems of attack were devised to meet different phases of naval engagement, but without due regard to a logical scheme of operations by the hostile naval commander. Joint maneuvers were frequently conducted wherein our Navy accommodatingly engaged in isolated operations for the purpose of providing the coast artillery with disjointed problems in tactics, instead of demonstrating in a logical, strategical, and tactical manner what our own Navy claims it can do to our forts when a maneuver is conducted on lines which we may expect a hostile fleet commander to adopt. When Commander Harris Laning conducted the maneuvers of the naval force operating from Boston to New York in the Fall of 1915, he not only prepared a program which satisfied all the demands of the coast artillery for a variety of tactical problems, but the maneuvers were handled in a manner that did not make it necessary for the Navy to stultify itself, and our land forces were taught lessons of the greatest moment by our sister forces. To attempt to prepare war plans for this vital sector of our coast-line, without considering these operations, would be most futile, resulting in an "estimate of the situation" but half complete.

IMPORTANCE OF LOCAL PLANS CAPABLE OF IMMEDIATE EXECUTION

I am in no sense belittling the importance of the local problems. They are invaluable in training officers, and constitute an essential part of the structure of war plans. Each post should work out a scheme for immediate action. Less than a year ago we gazed out beyond the horizon and wondered whether tomorrow would find us at war. If it had, would we have extracted from the safe, where our plans are carefully preserved, the papers telling us how many cubic yards of sand to pile up, and how much lumber to order for stockades? Such plans are highly desirable if the enemy is accommodating enough to delay his attack until they can be carried out, but the history of modern warfare gives us no right to expect that such consideration will be shown. War is hard, cold-biting, calculating, and lacking in sentiment. During the remainder of our days—those of us in the mid-career of our service—our Country will be neighbored by a latent military strength that can rise to the call of arms overnight. Why should an enemy delay striking so weak an opponent? The coast forts must face this situation on a *time* factor reduced to minutes.

The vital problem for local consideration is what can be done *today, tomorrow,* and the *next day.*

Camp the personnel near their units and dig cover or utilize the emplacements; screen the armament against aerial reconnaissance; provide sand-bag protection for observing stations, where possible, and cover more effectively subterranean lines of communication; shelter, against observation and fire, searchlight stations, casemates, and power plants; prepare defensive positions for the protection of elements of the defense against raiding parties; and provide and protect supplies of water and food. In fact do first everything possible with the men and matériel at hand or immediately obtainable. Then, when the cry which is sent out for men, money, ammunition, and supplies is answered, keep on working to make stronger that which you defend, if you are still in possession of it.

LOCAL PLANS MUST CO-ORDINATE WITH GENERAL WAR PLANS

For local plans of defense to be of value, however, they must co-ordinate with the particular centralized war plan that out national strategists may determine to use in meeting the situation which threatens. In estimating this situation paramount consideration must be given to the hostile view-point. The enemy will be past-masters in the art of war, and no plans to oppose or circumvent him will be of value unless based on sound principles and put into execution by trained strategists. Does any one question the worth of Lee to the South, or Grant to the North? Would the success of 1870-71 have been possible without the preparation and training demanded by Von Moltke? Only the egotistical mind of limited perspective, which considers personal enterprises of greater worth than national entity, will question the correctness of Admiral Fiske's statement that "in the real crises of a nation's life her most valuable asset is the trained skill in strategy that directs the movements of her forces."

In the preparation of war plans in complete detail, a quadruplet of basic considerations must be studied: policy, strategy, tactics, logistics. The initial, or working basis of the plans, deals primarily with policy and strategy. The question of tactics and logistics is in a large measure a matter to be handled by the local commanders at the time of an emergency.

In considering the particular war plan presented herein, the *conditions of today* interpret its significance. In the construction of the plan, the logical sequence of estimating any military situation will be followed.

POLICY OF A NATION ACCUSTOMED TO WAR

A nation which has dominated certain spheres of activities for centuries, prefers that the status quo be subjected to no violent change. If the empire has accomplished its growth by methods of peace and prestige, with the expenditure of minimum resources for those collateral guarantees of national existence, it will protest most violently against the threatening moves of an usurper. If a neighboring race strides to the front under the impulse of a national spirit which demands for its people larger fields of commercial activity and a more equal division of the spoils of world trade, who shall deny these people their place in the sun? The mainspring of national development is the right to live, to live comfortably. All pray to the same God; all believe that His protection encompasses them. The methods by which purposes are accomplished are foreign to this discussion, except in so far as they guide us in estimating the temper of the nation and in forming our own plans to meet the situation should our Country become involved.

The Premier of one of the present belligerent countries is reported to have stated, recently, that the man should be hung who, having at hand a weapon capable of doing injury to the enemy, failed to use it. He might have added, further, that the man should be blotted out of remembrance who, controlling conditions of today which imperil unborn generations, stopped short of any measure to save his people. What a terrible creed! Each can judge for himself as to the justice or injustice of it, but of such things is war. The ethics of life cause tribute to be paid to the man who, in shipwreck, sacrifices himself and those dearest to him to save the life of a stranger, but no such sacrifice of a nation by one controlling its destinies can be forgiven. A nation, a race, a people is greater than all things human. If war reaches the stage where it is no longer a conflict of armies, but a struggle for the very life of the nation itself, then must the militant forces fight with no thought other than the "will to conquer."

THE BURDEN OF DEBT SHOULDERED BY THE NATIONS AT WAR

The belligerents engaged in the present war will have accumulated debts at its termination upon which the annual interest, in several cases, will equal or exceed the cost of conducting the government prior to the war. The burden of debt cannot be provided for by the present generation—the legacy will weigh heavily upon the shoulders of those to come. The financing of the national resources will necessitate placing upon incomes, manufactures, and commerce a tax that will seriously handicap trade of all kinds in competition with the trade of the United States, which has fattened on the war. Why should a nation see its people suffer when the cause of much of the suffering can be removed? Would history condemn a nation did it take from *us* to give to *itself?* Does there exist today any part of the fabric of International Law or Relationship which would deter a nation, solely for ethical reasons, from taking such a step? Is *the man* to stop short in saving *his people* because it would pain *us*?

POLICY OF THE UNITED STATES

The policy of our Country is largely based upon the inert desire to be let alone. All well and good while acquiring our strength and limiting our domain to the confines of the Atlantic and the Pacific, but hardly world-satisfying now that we hold possessions reaching far into the East and the West. The maintenance of the Monroe Doctrine, while difficult at times, has been successfully accomplished largely through diplomacy; but today, and for years to come, Europe has millions of trained soldiers where a few years ago there were but thousands. We will be asked about the protection of European capital invested in Mexico. The trade with South America, which we are taking from Europe, will be fought for on the field of scientific production and salesmanship. China is an open market in which all nations will meet in deadly competition. And our Country will have the advantage over all others because our enterprises are not strangled by the tax of war. So in considering the policy which will influence the present European belligerents in their future dealings with the United States, keep in mind the immense interests at stake and reduce the situation to its basic elements: commerce, money, power.

Strategy of a Nation at War

When war was more a conflict of armies than a contest between the entire resources of belligerent nations, by strategy was meant the art of assembling and moving armies and fleets to accomplish the objects of the operations. Now that the entire "man labor" of a nation is organized as a source of military production and supply, strategy includes all the means adopted by statecraft and by the military in moving armies and fleets, in administering and supplying them, and in creating public spirit and national solidarity; all to accomplish the purposes of the war and terminate it with profit. Strategy can indicate a complexity of tentative moves, any grouping of which may have to be utilized when war breaks; and the modern nation studies itself and its neighbors from all possible political, geographical, and economic standpoints, so as to be best prepared to make a wise selection of plans when the need for their use arrives. All strategical plans, dealing with armies of immense size, possess more or less flexibility in the uniting of their component parts, so that a particular grouping of plans need not be discarded at the first indication that the other player in the game is not following the course expected of him. Sooner or later, however, the opposing armies will have fought and maneuvered so as to render inapplicable a further use of much that was contained in the initial scheme of operations; then only the big idea will stand forth, around which it will be necessary to construct new supporting ideas, so that the main object may be possible of accomplishment.

In estimating the initial strategy which an European enemy would employ if at war with the United States, we cannot consider the immediate objective except in its entirety of relationship—politically, geographically, and economically. The *time* factor in war has developed to an unprecedented extent in recent years. European strategists have learned to do things quickly. An enemy, determined to insist upon his demands at any cost, would be advancing against our frontier while our parliamentarians were still searching for a solution by pacific methods. The objective would be the Atlantic seaboard, somewhere north of Norfolk, followed by an attack on the Panama Canal.

THE STRATEGIC LOCATION OF OUR WAR PLANTS

In a supplementary report to the statement of a *Proper Military Policy for the United States*, prepared by the War College Division of the General Staff Corps in November, 1915, are two sketch maps showing the strategic location of military depots, arsenals, and manufacturing plants in the United States. "The shaded portions indicate reasonable and probable objectives for an invader, due to our present state of unpreparedness." A line running northwest from Chesapeake Bay to Lake Erie includes this vital area. If taken from us by an army of from 100,000 to 200,000 men, we would have to build up our military forces in the Mississippi Valley and construct new plants for the manufacture of all our munitions of war. Even our army does not appreciate how long this would take, more particularly for the creation of efficient fighting units.

THE TRAINING OF A "FIFTEEN MONTHS" ARMY

An effective army cannot be made today in the few months that we considered sufficient several years ago. We thought that six months intensive training of raw material would create a fighting body that would have a fair chance with any opponent. Sufficient thought is not given to the great advances made in the science of warfare and the psychology of the soldier in all European armies now at war. And it is this latter feature that is the more important, in that it is the more time-consuming. The mechanical training of the soldier, when conducted under the stress and enthusiasm of war, can be accomplished in six months; but if an army of six months training engaged in combat with an equal force from a modern European army, it would be slaughtered. It would lack leadership, cohesiveness, driving power. The division would melt away because the soldier still retained too much of his individualism. He has not been recreated mentally, physically, spiritually. Longer time, more training, are necessary to make of the man an atom that forgets self, willing to be lead and eager to follow to certain destruction, if by such a sacrifice the will of the leader can be accomplished. A "six months" army, engaged with the European soldier of today, will desert the battle-field after a twenty per cent loss and consider its efforts heroic. What our country must have to insure a fair fighting chance is a "fifteen months" army that will fight to extinction.

Indemnity the Primary Purpose of an Enemy

Were an enemy to invade our soil and hold the territory east of the Chesapeake Bay-Great Lakes Line, it would not be with the expectation of permanently acquiring territory within the limits of the United States after the termination of the war. Indemnity would be his purpose, and this can be levied, or attempted, by operations on a more limited scale.

A raiding force of five divisions, followed by an army of equal size, can occupy the line New York-Boston, demand tribute of ten billions of dollars or more, and hold this position until the sum is paid. With minimum effort the enemy obtains maximum results. If to the doubter this possibility is too fanciful or chimerical, I would advise him to take a quiet hour or two and ruminate on things of this war and write down the "impossibilities" that have been done on the battlefield; on the high seas; behind the lines, in manufacturing, commerce, finance; in the parliaments and the councils of war; all with the idea of keeping three leaps ahead of the enemy and making it impossible for the opponent ever to catch up in the race.

New York once in the hands of the enemy, and the City Fathers assembled by a Von Bissing and told that in two weeks a payment of five billions of dollars would be accepted, and at the end of four weeks another five billions, at which time the invader would withdraw—what would our Country do? For three days there would be an outburst of indignation, especially through the West, and a popular demand that New York be sacrificed and an army raised to drive the "insolent" invader from our shores. Then the voice of "big business" would be heard, and the cry of the populace drowned. In five days there would be started gigantic schemes looking to the concentration within New York City, before the termination of two weeks, of five billions of dollars in cash, or its equivalent. The other five billions would be forthcoming within four weeks; and we would then bid a sad and reflective good-bye to our guests and regretfully recall what "Preparedness" might have done. Congress would see that the Nation assumed the debt.

If our Country showed the hardihood to refuse paying tribute, the enemy would continue augmenting his strength within out territory until he was able to hold the line of the Hudson or the line Chesapeake Bay-Lake Erie, and our belated preparedness would begin its unfolding in the Mississippi Valley.

Construction of a Specific War Plan

THE HOSTILE STRATEGY

As it is the purpose of this article to present the outline of a single war plan, the situation is one where the enemy raids the most vulnerable portion of our coast. It is therefore necessary to consider in greater detail the foreign strategy which may be expected. In this plan the element of time has already been referred to as the vital factor. And that brings up the question at once: Would a hostile European country convoy 100,000 men across the Atlantic, without first acquiring control of the sea? Last Spring our Atlantic Fleet was in the Caribbean Sea at a time when each day might have found us at war. Our principal naval strength might be concentrated in the Pacific at the time when an attack from the east would be made. A coalition of nations might engage us with a combined naval strength so great as to render innocuous our entire navy. Or a single nation, using strategy of unexpected brilliancy, might hazard a convoy of fifteen or twenty transports before sea supremacy had been fought for. The move is not at all impossible, and not at all improbable, in view of the immense advantage which the invader would derive from striking quickly at New York and Boston.

Landing places for the troops and harbors for the fleet are easily found. Our coast could be invaded ten days after the mobilization of warships, transports, and troops had been completed. We would not necessarily have warning for ten days. Our first intimation that a vitally serious condition confronted us might come from wireless messages that a fleet and convoy were heading westward. A preliminary base would be established at Salem for land operations against Boston Harbor and Narragansett Bay defenses, and at Fort Pond Bay for the reduction of the defenses at the east end of Long Island Sound. Great Salt Pond, on Block Island, would be utilized by the smaller war vessels as a rendezvous for outpost duty and reconnaissance. How the enemy would estimate the situation in connection with the reduction of the coast defenses of Boston Harbor, Newport, and Long Island Sound by naval attack alone, I do not know. How some strategists in our Navy view these defenses I do not know, and I refer the inquiring reader to the several "estimates of the situation" prepared by Commander Laning when he operated in these waters in 1915. For the personal satisfaction of any coast artillery officer desirous of forming his own conclusions in this matter, I strongly recommend that he play a strategical war game on the hydrographic charts so easily obtainable from the Department of Commerce and the Navy Department.

DECISION OF THE HOSTILE FLEET COMMANDER

To continue the up-building of this war plan, it is assumed that the enemy formulates the following strategical decision:

To use a maximum fleet strength in convoying five complete divisions, with an auxiliary force of mobile artillery; and to effect a primary landing at Fort Pond Bay, a secondary landing at Salem, and a tertiary landing at Great Salt Pond on Block Island.

To reduce the defenses of Long Island Sound as soon as possible, and then concentrate three divisions at New London, two divisions on Long Island, and march on New York.

At the same time super-dreadnoughts would threaten to bombard New York City from the vicinity of Rockaway Beach, and results might happen so quickly with the defenses of the Narrows and Sandy Hook as to make it possible to move the army by transports into New York at once.

STRATEGY OF THE UNITED STATES ARMY

When we concentrated our regular army and militia on the Mexican Border last Summer, not a word was heard condemning the strategical disposition of the troops. Several pacifists bought whole pages in the daily press to advertise the unrighteousness of our Country's cause, and some extremists demanded that the army cross the Rio Grande in force at once. But there was no one who criticised the strategy involved in denuding our country of its organized military strength and placing it on our southern frontier. Were our eastern frontier attacked, however, there is no possible disposition of troops that would satisfy either the Government or the people. What would be accomplished by scattering 200,000 men from Portland, Maine, to Galveston, Texas? Nevertheless sectional demands would be so insistent that the War Department would have the greatest difficulty in overcoming them, and the possibility of satisfying them would be utterly out of the question. A condition confronts us which is the unwelcome offspring of our national policy—or lack of policy. Having no guiding principles to influence our actions if attacked by any other than a second- or third-rate power, our people have dulled their consciences with the oft-heard slogan: "Our army is the best in the world, man for man." There is nothing more fatuous that can be stated today. We are handicapped in many ways.

Our aerial service, military and civilian, has not practiced a system of battle tactics. Our mobile artillery has not grown in size to where it can cope with European 42-centimeter guns. We have but few machine guns. We have not practiced trench warfare, throwing hand grenades, using suffocating gases and liquid fire. All these instruments to kill will be turned against us when the first raiding divisions land. So our army is not the best in the world—by a long way.

NECESSITY TO DEVELOP STRATEGY BASED UPON A CONCRETE NATIONAL POLICY

If the United States is willing to do its own insuring against war and is satisfied to maintain only a nucleus of military strength, then let it be honest enough to so express its will, and the War Department will have a definite basis upon which to prepare a program. Our Congress should create a War Council that will possess inherent characteristics of permanency. Then would it be possible for the council to take what it finds in the way of military strength and say—"This shall be done, and sectional demands shall not sway us." To meet the situation presented in this war plan, the strategists in, and of, the War Department will indeed have to wield dictatorial power.

This plan contemplates the concentration of all available forces for the defense of the sector which we can least afford to lose. The force available is too small to attempt covering a line longer than from Boston to New York. If the initial attack is not made on this front, but along the Delaware or the Chesapeake, nothing whatever can be done to oppose the landing, yet the small army is still best disposed to cover New York from the south. The coast-line south of Virginia will have to be sacrificed, as will all our Gulf ports. It will take the power of a Bismark to issue such a concentration order to our militia.

TROOPS IMMEDIATELY AVA LABLE

For the purposes of this plan it will have to be assumed that the mobile army is no longer on the Border, and that the militia have returned to their respective states. Of the latter force there are about six divisions that have had excellent training in recent months. But let no one be deceived as to their fighting caliber. Remember that today it is only the "fifteen months" trained soldier whose psychology is so regenerated as to make of him a worthy opponent to his brothers-in-arms across the seas. This militia of today will go into battle and give its all—its life—but it will not, it cannot, give its Country success. Of the regular troops there will be about three divisions, handicapped in the way of matériel and training as already indicated.

In determining the strategical disposition to be made of this force, begin at the coast-line. The forts must have at once personnel to man all the armament with one relief, the details of which will be discussed more fully later. Large mobile units must cover Long Island and Connecticut, and it is the placing of these troops that constitutes our most difficult problem. If it were estimated that the enemy would attack Sandy Hook first and effect a primary landing near New York, the army would have to be concentrated near New York. If it were thought that the advance would be made via Long Island, then the three divisions of regulars should be located there. If the main advance is by the mainland north of Long Island Sound, with a flank column on Long Island, then our line would have to extend from Long Island into Connecticut. As the conclusions arrived at in estimating the situation from the enemy's standpoint were that the main advance would be by the mainland, with a flank column on Long Island, and an immediate diversion in close proximity to New York, this plan is prepared to meet such conditions.

CONCENTRATION OF THE REGULAR DIVISIONS

Our main point of concentration for the regular divisions should be between the Connecticut and Hudson rivers, with the right extending to Long Island. The highways and railways throughout the entire area under consideration are so numerous and of such excellent quality that the system of transportation of troops, munitions, and supplies, by rail or truck, would soon be developed to a maximum degree of efficiency. If the enemy appeared in force off the forts of Boston, Newport, or Long Island Sound, and delayed landing operations until the coast defenses fell, time might be had to divert one or two divisions to the threatened point. But during the first days of concentration, under no conditions should the main combined strength of the regular divisions, west of a north and south line through the Connecticut River, be weakened by detaching large units for the local defense of the several forts mentioned. The three divisions should be kept practically intact, mobile to the highest degree, and so located as to possess the greatest strategic possibilities. Water transportation on Long Island Sound will make a continuous line of the right and left wings of the selected position.

The line of the Connecticut River forms a strong natural barrier which will strengthen the position very considerably. To be east of this river has two objections: First, spies or hostile sympathizers amongst our own citizens might destroy the several bridges across the Connecticut. It would seem on first thought that this is a contingency easily provided for by placing guards; but we have had in the past two years some very illuminating examples of what can be done by those whose sympathies are strong for the old country. Second, a position along the Thames is too far east and can be turned if the enemy effects a run-by of the Terry-Mansfield line after a brief engagement. He would steam through the Sound with his transports and place his army outside of New York before our forces could be moved to the Hudson. A concentration on the Thames, or at the head of Narragansett Bay, would be permissible only in case it was known that the main hostile strength would move overland from Boston, and there is no reason for assuming that he would employ such strategy while other routes to New York City are more direct.

If the secondary attack at Salem and Boston is conducted with élan, the sector east of the Thames cannot be held. But no matter how rapidly the operations at the east end of Long Island Sound are pushed forward, the three divisions are favorably posted to oppose an advance west of the line Fort Pond Bay-Thames River.

There is still one more element in the time factor to consider which represents the extreme of unfavorable contingencies—the appearance of the enemy on our coast may occur before there is an opportunity to concentrate the three regular divisions west of the line of the Connecticut River. Should this occur this plan will have to be modified to the extent of placing along the Connecticut River line as great a concentration as possible, and let this force fight a step-by-step defensive until joined by the remaining incoming regiments.

CONCENTRATION OF THE MILITIA

All of the militia, with the exception of the coast artillery reserves, should be concentrated west of the Hudson and north of New York City. To order a concentration of this portion of the national army, in the sector designated, will require a tenacity of purpose on the part of the strategists which will be strained by much of the public press almost to the breaking point. It will be a test of strength and determination that may result, due to popular clamor, in the downfall of the commander who orders it. But in the first months of our travail it is not to be expected that any portion of the regular army can hope to escape unscathed, thanks to the nation's general condition of unpreparedness. Our handful of trained troops can expect to go out, and fight, and die, and their deeds will soon be forgotten in the more momentous happenings which will speedily follow.

If our six divisions of militia had had six or eight months more training on the Border, and if the personnel which would respond to this call were the same that went to Texas, these troops could be placed in the first line east of the Hudson at once and the enemy's plans greatly modified and hampered thereby. His initial raiding force of five divisions would encounter superior numbers at once, and the task of occupying New York City would become more difficult. This, of course, in no wise affects the possibility of the fleet's bombarding the city at long range.

But to place the militia in the first line where they would be engaged, probably before the concentration had been completed, would be to sacrifice them in a manner which no leader could justify. If their opponents were soldiers of the school of three years ago, I would say put the militia on the Connecticut River; but the quality of the European fighting man of today is so greatly superior to what it was before the present war, that civilians of our Country cannot expect to reach this super-grade of training and efficiency simply because they are patriotic enough to give their lives in defense of their Country.

By placing our citizen soldiers west of the Hudson they are given a breathing spell during which it may be possible to complete their concentration and give them further intensive training to increase their measure of efficiency. It is quite possible, however, that they may be called upon early in the war to offer up their sacrifice; for if the enemy is in sufficient force, and opens up the defenses of Long Island Sound, or of Southern New York, in the short time in which it is possible for him to do so, the regular divisions will have more than they can attend to, and the militia will have to move to the front at once. It is the anticipation of some such hostile strategy that renders it necessary to place part of the New York Division just east of the Hudson, in immediate support of the inner line of coast defenses. Then, if the line fails to hold, the Nation may as well turn its eyes to the Mississippi Valley.

Think of what has become of the four divisions of regulars that constituted the British Expeditionary Force to France. The public does not know that Ian Hamilton, with all his "paper" strength of 100,000 men off the Gallipoli coast in April, 1915, planned to effect his main landing with one small division of regulars; that this division was in the trenches at Helles for seventeen days, fighting almost every hour of the time, before all the 42nd Territorials were disembarked and sent to relieve it. How long did it take to make the Kitchener army? How long to train the Derby recruits? Britain now gives her men fifteen months training before sending them into the first line trenches.

DECISION OF OUR ARMY COMMANDERS

A summarization of the strategical dispositions, to be made of our forces in building up this war plan, results in the following decision. Coast artillery reserves throughout the United States are sent to their respective forts. Should there be a shortage of men to furnish one relief for all the armament at all forts, state troops will be detailed to make good this deficiency. A brigade of militia will be sent to Portland, Maine, as support to the defenses of that harbor. A regiment of militia will be sent to Portsmouth. A reinforced brigade of regulars will be advanced from the Connecticut River position for the support of the Boston defenses. Two regiments of regulars will be advanced to Newport. A regiment of militia will support the New Bedford Harbor position. A reinforced brigade of regulars will be advanced from the Long Island division in support of the defenses at the east end of the Sound. The New York militia will place a brigade at Sandy Hook, a brigade at Forts Hamilton and Wadsworth, and a regiment at Fort Totten. The concentration of the regular divisions will be west of the line Greenport-Connecticut River. Defensive positions will be constructed covering the Thames and Connecticut Rivers. The main body of the militia of the United States will be concentrated west of the Hudson.

SUMMARIZATION OF THE FORCE BEHIND POLICY

The construction of this war plan has now progressed to the point where a more intimate discussion of the details called for can be engaged in. But before proceeding with the local phases of the problem, I want to recall briefly the significance and importance of the several steps already taken. Policy is generally said to rest in and with the people in any democratic form of government. This statement is not correct if interpreted to mean that the people dictate or initiate policy. No more so do they create new legislation. This is done by party or national leaders; either as a party measure, or on the broader lines of good statesmanship. Leadership in the United States is awakened to the necessity of preparedness. The public is following this lead; enthusiastically in some sections, with chilling indifference in other sections. The only reason for interest in preparedness is that our policy is being reshaped. The European war forces itself into every avenue of our lives; we cannot escape its effect now; we will not cease to live in the shadow of its menace during the next decades. So leadership must give to our national policy more thought, and concrete ideas must be evolved. With the expression of a public sentiment which may have the ring of truth and the appearance of permanency, building for the future to enforce the "will of the nation" can be planned. Strategists can prepare war plans which will give protection to our Country, because of the adequacy of the force at hand to carry them into effect.

The fact that this ideal condition does not exist now, makes the need more pressing that war plans be prepared on the sole basis of what the Country has today for its defense; that we wait no longer to meet a possible and probable emergency with a scheme of defense either half prepared, or one calling for the employment of troops and the use of matériel not at hand. No one war plan, even for operations in the same theater, can be so comprehensive as to cover all reasonable contingencies of hostile offense. Our regular army and militia are such a small handful of men that without dense concentration they will not be able to strike even a weak blow. Clearing the seacoast states in time of war of a force which is largely looked upon as having been created for local protection, will meet with such pronounced opposition that, unless our War Council is so big as to command the confidence of the people, the execution of the plan will be stopped, or may be fatally delayed.

We concede that the vital portion of the United States lies north of Virginia, centering around New York. Therefore the defense of New York City is necessary even though the enemy makes no direct thrust in that direction, but over-runs, unopposed, numerous other portions of our coast-line. Should the initial raiding force operate south of New York, it would signify that a large army was to be lead against us, in which case we would finally be compelled to retire into teh interior to make an army. Were the raid conducted against New York City, a quick decision and a demand for indemnity would be the immediate hostile mission. It is in anticipation of such a mission that this war plan has to do: the placing of the troops immediately available so as to offer the most effective resistance in thwarting the enemy's purpose in this bid for large returns for a small effort.

LINES OF DEFENSE

East End of Long Island

In the decision, a force of one division is to constitute the right wing of the concentrated mobile army of regular troops. From this division a reinforced brigade is to be advanced to support the coast defenses. The division will base on Riverhead, and hold both forks of Long Island which project from there. The southern peninsula is the more important, because the most logical place for a hostile landing, Fort Pond Bay, is located there. We have no mobile artillery to use in denying the enemy this landing, and the planting of mines would be a menace easily removable by sweepers. Defensive positions will be prepared: First, in the hills west of Promised Land, covering the neck south of Gardiners Bay; then in the Shinnecock Hills. Afterwards another line will be laid out between these two positions, where the peninsula widens. The importance of the northern fork is due to the fact that mobile artillery can take the defenses of Fort Terry in the flank and rear from any position east of Orient. In addition, communications will be maintained with Forts Terry and Michie by way of this fork. A brigade will hold this end of the island and prepare defensive positions in the vicinity of Southold and Mattituck.

The Fort Terry-Fort Mansfield Line

The reinforced brigade for the support of the coast defenses will be distributed as follows: A regiment of infantry, two batteries of field artillery, and two platoons of cavalry on Fishers Island, one company of infantry being detached to Fort Mansfield; a regiment of infantry, two batteries of field artillery, and one platoon of cavalry on Plum Island; and a regiment of infantry and a platoon of cavalry covering from Orient to Orient Point. There would be no supports on Great Gull Island because of the number of troops required to man the armament.

If war plans developed on the lines of this one were placed in the hands of coast defense commanders, they could determine more understandingly the matters for local solution. With the distribution of troops being given, the Commanding Officer of the Coast Defenses of Long Island Sound covers the front Orient-Watch Hill—his position on the right being based on Riverhead, via Greenport, and on the left on New London.

The troops placed at his disposal are not sufficient to render the position impregnable—far from it; all that can be hoped for is to cause some delay. The hostile reconnaissance along this front will occupy a greater length of time because of the brigade of infantry in support of the line, even though the power of resistance of the latter is a relatively negligible quantity.

At this point, I would like to bring to attention a time factor not usually considered in connection with joint, amphibious operations. If it is estimated that the hostile navy alone can break the line Fort Terry-Fort Mansfield in two days, if unsupported by infantry; and that with a small infantry support the line will hold four days, because of the necessity for more careful reconnaissance; then the actual period of delay gained may amount to several weeks, owing to interruptions in the operations caused by unfavorable weather conditions. The reduction of the outer forts of the Dardanelles in February, 1915, was an extremely simple matter, taking less than two days of operations; but northeast storms interrupted the work to such an extent that the Straits were not entered to any considerable degree for two weeks.

Local Work for Reserves and Supports

The solution of the local problem for disposing of the coast artillery troops, reserves, and supports would be undertaken with greater zest did the fort officers know what personnel they were to receive, and how the scheme for local defense fitted into the general strategic plan involved in the entire theater of operations. No matter how onerous are the demands made upon the coast artillery at the outbreak of war, one complete relief manning the armament can handle the situation for a time—at least until the enemy's plans develop and the point of attack is known. There will be constant work for this personnel, other than in its drill, in constructing shelter and providing more effective cover for armament, matériel, and accessories. The support will be entirely new to their surroundings; and the contemplation of an enemy appearing from beyond the horizon will be so novel as to tend to disquiet them, until they shall have become shaken down in their new surroundings. This, of course, will be much facilitated if camp sites are known, defensive positions planned, and the scheme of defense worked out in such detail as to make it possible for the support, on being landed at the dock, to continue to the front and take up a position, which, in effect, amounts to a "position in readiness."

Strength of the Long Island Sound Line

It is not the purpose of this paper to analyze the strength of the line Orient-Watch Hill, but it is my opinion that it is as weak as would be the position of a division were it to hold a single line on a twenty mile front, against the advance of an army. An officer can study this problem for himself, even without the aid of the war game for this coast defense; in fact, he will find that the strategy of maneuvers is more readily comprehended from a study of the topographic and hydrographic sheets than from playing the Coast Artillery War Game, where so much attention is usually given to details of drill. But if the possibilities and limitations of this area are inquired into, make sure that your studies include an "Estimate of the Situation" prepared by some competent naval officer.

When the enemy has once penetrated this line there will be no escape for the defenders of Plum Island, Great Gull Island, and Fishers Island. The support, augmented by battery personnel released from units no longer in action, will fight landing parties until overcome. They will not be reinforced; the position, as an outpost on our frontier, has no further value; hostile transports will steam into the Sound; our army will have to fall back on New York.

You may ask, why prepare a war plan wherein it is known that the advanced positions cannot be held against an aggressive enemy? Because no advanced positions of an army on the defensive are expected to hold indefinitely. They delay, but do not defeat.

Another question: In view of the small army available on the outbreak of war, why risk several brigades, and maybe the entire regular army, by advancing the line fifty or one hundred miles east of New York, instead of sacrificing New York City without a fight, thus saving the regular divisions as a nucleus around which to construct an army west of the Hudson? Because there are situations wherein the loss of an army is as nothing compared with the loss of national honor. As a moral factor of pre-eminent weight, influencing the months and years of war which may follow, our strategists had better knowingly sacrifice the regular army in defense of New York City, or some other vital area, than to concentrate it to the rear in order to save it.

Linking Together the Advanced Positions on Our Frontier

Geographically, the frontier which we expect to hold in time of war should be the line of the advanced positions represented by the harbor defenses. Strategically, this is impossible to do until there have been developed plans for the defense of intervening sections of coast-line. It is the essential problem confronting the Country today. Its correct solution is dependent upon the careful analysis of what has been done during the present war. The War Department Board of Review recently revised the approved projects for the defense of certain harbors, as prepared by the Taft Board. Among the more pressing requirements submitted in its report of November 26, 1915, are included the following:

> The utilization as howitzers of 36 of the surplus 12-inch guns now on hand by mounting them on barbette carriages of a special design that will permit of the attainment of a range of 30,000 yards. * * *
>
> The retention of the disappearing carriage as the type mount for direct-fire seacoast guns, except in those instances where special conditions may render advisable the installation of the turret or barbette mount.

I am opposed to the permanent emplacing of more guns along our seaboard, except those of 16-inch caliber. Where additional armament is to be located on islands to strengthen the harbor defense, it should be *positioned*, not *emplaced.* It is cutting off the length of the fighting arm one-half to assign a defensive rôle solely to large caliber guns, as is done when they are emplaced and thereby immobilized; for it is mechanically possible to preserve their mobility and thereby place them in the category of offensive weapons.

The vulnerability of a disappearing gun carriage is a matter of grave concern. I am opposed to the construction of any more carriages of this type, and believe that those now in use should be protected with a two-inch splinter proof. All these questions can be settled to the personal satisfaction of any one who will carefully analyze the operations at Tsingtao in 1914, and along the Dardanelles in 1915. No matter whether or not your final deductions are in accord with mine, if they are based upon an understanding of these campaigns, so important to the coast artilleryman, they will be valuable to the extent in which you may profit from the study.

The Supports at Portland, Portsmouth, Boston, and Newport

In the assignment of coast artillery supports, a brigade of militia is held at Portland Harbor. Next to Boston, Portland is the most important harbor on the northeast Atlantic. If any of the enemy's primary activities are directed to the Maine coast, this small force, unsupported by any portion of the mobile army, can accomplish but little. On the other hand, if the enemy is engaged primarily against Boston and New York, the presence of 4500 rifles, supporting the harbor defenses, would deter him from raiding Portland with a small force merely as a side diversion. A regiment of militia would be held at Portsmouth for similar reasons. These four regiments could not be expected to join the main army were a withdrawal on New York necessary.

The reinforced brigade of regular troops, advanced from the Connecticut River position in support of the Boston defenses, will be assigned to positions and commanded by the coast defense commander so long as these defenses hold out against the enemy. Should a landing in force, say of one division, be made at Salem, and the Boston defenses turned, this brigade would rejoin its division either on the Thames or west of the Connecticut. It would be impracticable to advance a division to its support, unless it were clearly demonstrated that the enemy did not intend to force Long Island Sound.

The situation in connection with Narragansett Bay is somewhat different. The naval station at Newport would be an immediate hostile objective; and in planning the defense of the line of the Thames, consideration should be given to the probable advisability of having a division on Narragansett Bay. Entraining facilities for a move from east of the Thames to Wickford Junction, and water transportation from Wickford Landing to Newport, should be prepared as soon as the order of concentration is issued, so that two brigades may be moved in the minimum of time. By a night movement it would be possible to reinforce the Newport position and have a division to oppose the enemy. The danger in this strategy lies in the fact that the Fort Terry-Fort Mansfield line might be penetrated in a brief maneuver, resulting in the occupation of the Connecticut mainland and the cutting off of this division from New York.

Resistance Offered by the Long Island Position

We will return now to a further consideration of the southern end of the line of concentration, Long Island. This war plan is based on the hypothesis that the primary objective of the enemy will be Fort Pond Bay. This is an ideal harbor to use as an initial base, there being sufficient depth of water and a good anchorage. Of course, as the operations developed, it would be necessary to secure a more conveniently located base equipped with drydocks and repair facilities, and these are found at New York, Boston, Portsmouth, and Newport. But for the reduction of the defenses of Long Island Sound and Southern New York, the operation would be an amphibious one, and the occupation of the east end of Long Island, for the purpose of taking Fort Terry in the flank and rear, would doubtless be attempted. The further advance on New York by Long Island would then be either by land, using motor service, as no railway cars would be captured, or by transport through the Sound.

The resistance which the division of regulars could effect at the Promised Land (the neck south of Gardiner's Bay) and the Shinnecock Hills positions would depend largely upon the manner in which the defenses were organized, the important factor being the construction of modern type trenches in which the troops would have a fair amount of protection against the fire of mobile artillery in superior numbers and of greater weight. The hostile navy would supplement the land fire, and their bombardment of the flank and rear of the several lines, from positions a mile off the south shore of Long Island, would soon make these defenses untenable. But here again the all-important time factor must not be forgotten. High seas in the Atlantic might interrupt the attack for a day or a week, and it is mainly due to the possibility of some such delay occurring that a first position so far to the front is taken up.

Withdrawal of the Line

The time when it will be necessary to withdraw the Long Island division will depend upon how the operations develop in Connecticut. Ample transport facilities on the Sound will make the transfer of troops from the Thames to Long Island a quick maneuver, should the army commander find that there was no great pressure on his Connecticut position. When the withdrawal of the entire line does become necessary, the Connecticut divisions will fall back on their main position between the Connecticut and Hudson rivers. These lines cannot be laid out with certainty from a study of the topographic sheets alone; it is necessary that the terrain be closely investigated, and tentative lines be decided upon after viewing all this area. The Long Island division would fall back on a line through Half Hollow Hills and Dix Hills, north of Babylon. As it will probably be necessary to effect the withdrawal with the utmost rapidity, prompt movement of troops will have been provided for by mobilizing trains and automobiles in rear of the line.

While this latter position is being occupied, it will be necessary to reinforce the greatly depleted regular divisions by placing the militia in the first line. One division will cover New Jersey and Staten Island, the other divisions will move east of the Hudson on both sides of the Sound. It is to be hoped that the regular divisions will have been able to bring about a delay of sufficient length to insure the concentration of the militia and its organization into divisions. If the line in front of New York, when reinforced by the militia, fails to hold, it will be because the entire available fighting strength of the Nation is overpowered and our Country is without further defense until a new army is recruited, trained, and supplied.

Conclusions and Recommendations

An army of a million men of fifteen months training is necessary to safeguard the Atlantic and Gulf frontiers. One-half of this force would cover the area from Chesapeake Bay to Portland, Maine; the other half would be distributed along the South Atlantic coast and the Gulf of Mexico. To prepare for defense against a coalition of eastern and western nations would require an additional half million trained soldiers for the Pacific coast. Very few people realize that Canada has trained an army of about half a million men to be used overseas. Second line troops to the extent of a million and a half should be concentrated in the Middle West area to complete their training. Any one interested in inquiring further into this matter should read the report prepared in 1915 by the War College Division of the General Staff on *A Proper Military Policy for the United States.* The strategic areas represented by the East Atlantic states, the Gulf states, California, and Puget Sound, are very clearly defined in the report. It includes a table showing the preparedness of the great powers for over-seas expeditions, based upon conditions as they were in August, 1914. The time needed by Germany to load and cross the Atlantic with a first expedition of 387,000 men and 81,270 animals is 16 days.

Our frontier should be our coast-line. To effect this it is necessary to connect the line of harbor defenses which stand now as isolated advanced positions. This is a matter which is receiving more close attention than any other single military problem. Its solution depends in a great measure upon questions that are entirely mechanical, pertaining to the construction of mobile guns of large caliber. There are certain basic principles which should guide, however, in the construction and handling of these new weapons. They must be powerful enough to anticipate development on similar lines by rival nations. The mobility of the machine should be insured, the carriage should be capable of operation either on a railway roadbed or on a highway. Batteries intended for operation along highways should be provided with sections of transportable railway, so as to enable them to go into position off the highway. No more harbor defense armament should be permanently emplaced, except 16-inch guns and mortars. All other armament, intended to increase the power of seacoast forts already established, should be positioned only, thereby preserving their mobility and transferring them to the active rôle of an offensive weapon, instead of lessening their efficiency by limiting them to a semi-negative defensive rôle. The enemy will have greater difficulty in locating this armament, and the batteries can be utilized as a mobile force along the seaboard.

ANTI-AIRCRAFT WEAPONS

By Major ELMER J. WALLACE, Coast Artillery Corps, U. S. Army

Since aircraft have sprung into such unforeseen importance as instruments of war, the necessity of devising means to combat them has been universally recognized. As is to be expected in the case of such a rapid development, the methods and means of attacking them have been, of necessity, several phases behind the progress in development of the aircraft themselves. This position of inferiority was inevitable so long as progress in flight continued to be evolutionary from month to month.

Evidence is not wanting, however, to indicate that the limits of mechanical flight are being approached experimentally; and that so long as no new principles of support or propulsion are discovered we are now able to foresee approximately the power and general characteristics of the machine we have to oppose. But in saying that the aerial field has been roughly explored experimentally, it must not be understood that the practical limits of development within this field have been approached. For example: airplanes have developed a weight-lifting capacity of fifteen tons, yet practically no machine has been devised to utilize this capacity for the carrying of guns, armor, and personnel. Tactically, also, the employment of airplanes is in its infancy, and the scope of their future activities is an open field for the intelligent employment of the imagination.

Attacks upon aircraft fall into two classes:

1. The attack of aircraft by aircraft.
2. The attack from the earth.

Gunfire is the prime method used in both cases, and will be the only means discussed in this paper. Unfortunately our knowledge of the means and methods employed in the European armies are complete only to the time of the outbreak of the present war; later than that we have only such scraps of information as the several military authorities have permitted to pass.

Manifestly the character of weapons to be employed from aircraft and from the earth will be different; yet in certain particulars—as, for instance, the character of target and the relative advantages of the several projectiles—there will be much in common. When its nature permits, the following discussion is general to both; when not so applicable, its limitations will be readily apparent.

Targets and Projectiles

Three targets present themselves to the anti-aircraft gunner: The captive balloon, the dirigible, and the airplane.

The captive balloon and the dirigible are in the main alike as targets. The principal area of presentation in both cases is the large gas-bag of light fabric enclosing a highly inflammable gas. In addition to the gas-bag they present a relatively small, but more vulnerable, area in the operating personnel in both cases, and in the machinery of the dirigible. Small punctures in the gas-bag are not serious, because the elasticity of the fabric tends to close them; and, as the gas in the present types is not much above atmospheric pressure, the gas escape is of slight consequence.

The aeroplane presents a much smaller target, consisting principally of the wing-area of fabric, the light spar frame, control-wires, propeller, gas-tank, motor, and personnel. Only the gas-tank, motor, and personnel are likely to be disabled by bullets from small-arms. Shrapnel, and even large projectiles, may pierce the wing-fabric without serious damage. Furthermore, in most of the machines now in use, the personnel and the more delicate parts of the motor, as well as the gas-tank, are protected by light armor against small-arms bullets and shrapnel balls—at least, from below.

The latest information indicates that the employment of armor has become almost universal, except for high-speed, high-flying machines intended for the attack of other craft from directions in which they are unable to protect themselves with armor or effective gun-fire. The thickness of armor used is from 3.5 to 4.5 mm., and in the heavier machines it is so distributed as to give almost complete protection to the delicate parts and personnel, except from above. For guns on the earth, and for those mounted in aircraft, the airplane target must be assumed to be armored, except such aircraft as are assured the choice of position by their superior mobility. The frame of airplanes is generally of spruce or steel, the latter being exclusively used by the Germans, and now quite generally by all nations. The control-wires are frequently in duplicate.

As to dirigible and anchored balloons, their vulnerable point is the large inflammable gas-bag—and on this the attack should be centered. Apparently this is being done, as we have frequent accounts of their falling in flames. Certainly such an attack presents no insurmountable difficulties. A small flaming projectile, like that of an exaggerated Roman candle, is mentioned as being used at short range by other aircraft. A very light projectile, bursting on impact, with an explosive charge giving momentary persistence of flame; a shell with flaming base, as in the Semple tracer; a shrapnel-like projectile discharging a mass of burning compound similar to that of incendiary bombs—any, or all, would certainly prove effective. Numerous accounts indicate that such devices are now in use, but unfortunately we have no definite information as to their exact nature.

It has been believed that the burst of a high-explosive shell in the vicinity of a gas-bag would rupture it, due to the air disturbance, even if no damage resulted from the fragmentation of the shell; but there is no evidence to support this theory. It does not seem possible that sufficient damage can be done by detonation alone near the gas-bag, unless the shell is of greater size than the limitations of the anti-aircraft gun permit. The proposal to overturn aeroplanes by air disturbance, in a like manner, offers little prospect of success.

The aeroplane is the much more difficult target because of the difficulty of producing disabling results by hits on the small vulnerable area presented. When the aeroplane is not armored, or where the armor does not afford protection from the direction of attack, there seems to be no doubt that rifle bullets and shrapnel balls—because of their great number and increased probability of hitting the pilot, gas-tank, and delicate parts of the motor—afford the most effective projectiles. Where, however, armor is effectually placed, these projectiles are ineffective, unless the burst of shrapnel be so close as to cause the balls to strike a cumulative blow. They might be made more effective by the use of balls of greater weight and hardness. Small bullets are entirely ineffective against the wing-surface. The frame, if of wood, permits their passage without dangerous weakening; and, if of metal, resists them. Propellers are not seriously injured by bullet-holes. All this is evidenced by the fact that as many as 400 holes have been counted in a machine that was found to be still serviceable.

High-explosive shells, with time-fuses, are reported as effective; and this is naturally to be expected, provided the fragmentation is not too great. Shell-fragments of moderate size should break down such armor as an aircraft can carry, and should cut the framework of the craft, carry away controllers, and wreck the propeller.

It is not considered possible to provide fuses of sufficient sensitiveness to give bursts against balloon- or airplane-fabric, except for projectiles of two pounds weight, or under. The retardation is not sufficient with heavier projectiles to cause the fuse to function. Light, sensitively-fused projectiles would, however, be effective at short ranges against any part of an aircraft.

Incendiary projectiles, except by chance, would be ineffective against aeroplanes. Unless the gas-tank is struck, the latter are not likely to be set on fire.

One other consideration with regard to projectiles should not be lost sight of. It is expected that the percentage of hits, owing to the difficulties of fire direction, will be exceedingly small, and that the number of shots fired must be consequently large. Usually these projectiles will fall in friendly territory. If fired at high angles, rifle bullets and shrapnel balls will fall at such low velocity as to greatly reduce their powers of doing damage; but explosive shells, with percussion fuses, will be a serious menace to inhabitants and troops.

As to the weight of the shell employed with the time fuse, it does not appear possible to get an effective shrapnel of less than ten pounds; while the greater the weight above that, the greater the number of missiles and the probability of hitting. The same holds true for high-explosive shell, although effective results might be obtained from the latter by using as low as six pounds weight, from the burst of which four to six effective fragments might result.

The use of day and night tracers in projectiles would appear to afford great advantage to the gunners in directing their fire, and should certainly be tried with all calibers large enough to contain them.

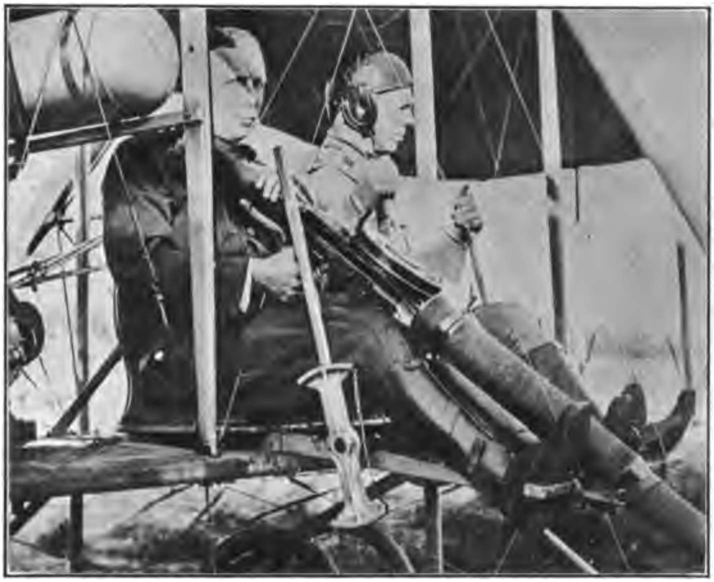
Guns to be Mounted on Aircraft

So far as our topic is concerned, the gun so mounted is for use against other aircraft. Recent events in Europe indicate that it will also be employed against land troops, and this will to some extent modify it as finally adopted.

Up to the present the fighting by aircraft has been at short range and, no doubt, will continue so. Therefore, low ballistic power will suffice.

The suitability of guns for mounting on aircraft is subject to numerous limitations and requirements, among which may be mentioned:

1. The weight of the gun, mount, and ammunition must not be excessive.



The Aero Club of America Bulletin. 1187

FIG. 1. CAPTAIN CHANDLER READY TO BEGIN AEROPLANE FIRINGS EMPLOYING THE LEWIS GUN AT COLLEGE PARK, MARYLAND, JUNE 8, 1912

2. Its recoil must be so controlled as not to over-strain the fragile craft.
3. It should be capable of short bursts of very rapid fire.
4. It must be so mounted as to permit fire in any direction, except when used on a craft of as high, or higher, speed and maneuvering power than anything that can come against it.
5. It must be effective against the intended target.

The arming of the aircraft began with automatic pistols, infantry rifles, and machine guns. The latter, particularly the Lewis gun, has remained the arm of the lighter high-speed craft. The heavier craft have adopted, in addition to the machine guns, the Avion cannon, with which both France and Germany have achieved marked success. Of the German guns we know practically nothing, but of the French guns we have enthusiastic reports.

It is of 37-mm. caliber, and presumably fires a projectile of about two pounds weight. It is well suited to attacking airplanes and, if furnished with incendiary projectiles, it should be effective against dirigibles and captive balloons.

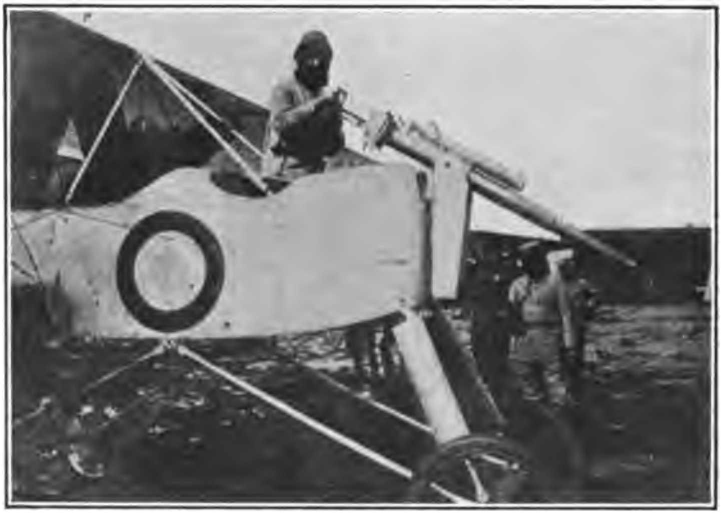


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FIG. 2. NACELLE AND QUICK-FIRING GUN OF A FRENCH AVION CANON

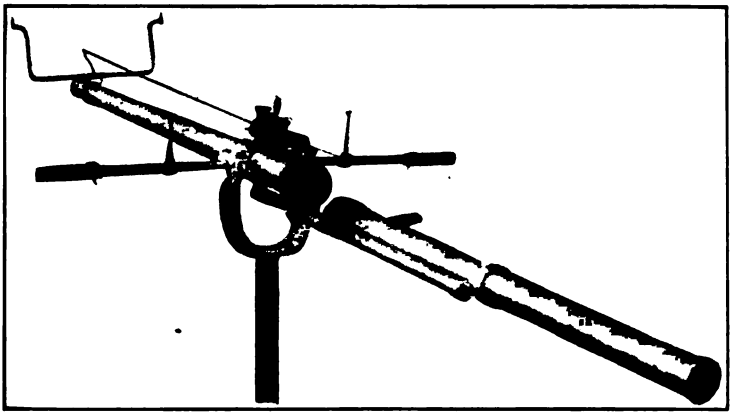
It may be presumed that this gun is the largest so far found suitable as to weight and recoil for mounting on aircraft. The gun appears to be hand-loaded. The advantage of an automatic—even if of a somewhat smaller caliber—would be so great in view of the short, favorable presentations of the target, that it is not understood why it has not been used.

Reports frequently mention non-recoil guns. Unfortunately they are usually vague as to how the non-recoil is effected. Captain A. L. Fuller, Coast Artillery Corps, U. S. Army, gives the following description of such a gun of American design:

> This type has been experimented with locally by flyers at the Curtiss Aviation School, at Newport News, Va., and has been successfully fired from airplanes. It consists of two separate tubes which are joined by an interrupted screw-thread. The front barrel takes the fixed ammunition

and is, of course, rifled. The rear barrel is a smooth-bore. The cartridge case is of brass and is quite like fixed ammunition in appearance. The projectile occupies one end, the propelling charge the mid-section, and the recoil charge of lead shot the rear end. When the piece is fired the force of recoil is taken up by the expelling of the charge of small shot to the rear. The field of fire is limited by the necessity of keeping the rear end of the gun pointed clear of the aeroplane. These guns have been made in the 2-, 6-, and 12-pounder sizes. The 2-pounder is 10 feet long, weighs 75 pounds, the diameter of the bore is 1.575-in., and the M. V. is 1200 f. s. The 6-pounder weighs 130 pounds; and the 12-pounder, 210 pounds. The latter is of 3-inch caliber and its M. V. is 1100 f. s.

The double limitation imposed upon the field of fire of this gun, together with the additional weight of projectiles, will greatly reduce its usefulness. It cannot be expected that the craft carrying it will be of the most mobile type. Therefore the machine must carry other guns to give protection in all directions, as it has been fully demonstrated that there is no place in the air for a moderate-speed craft with a "blind side."



Scientific American. 1931

FIG 3. NON-RECOIL GUN WITH BREECH OPEN FOR LOADING (ALSO SEE FIG. 4.)

A so-called "non-recoil" French gun is described as being thrown forward in its cradle by compressed air; at the moment of the highest forward velocity it is fired automatically; and the recoil returns it to its original position, where it is held until reloaded for the next shot. The recoil is taken up by the forward momentum of the gun at the instant of firing and by the re-compression of the air. Such a gun would, as far as the stress upon the mount is concerned, be not non-recoil, but long-recoil, the stress beginning as the gun starts forward and ending when it finally comes to rest.

craft. Th [illegible]
machine g [illegible]
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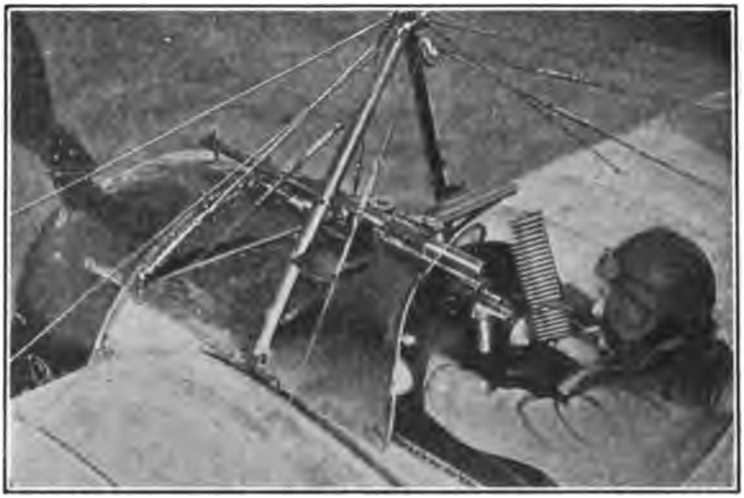
must also be the gunner. Here the gun is rigidly attached to the fusilage, pointing forward through the propeller, and is intended for use only in pursuit. To avoid destroying the propeller the Allies have armored its blades at the point passing through the line of fire, thus deflecting 30 per cent of the bullets. The Germans, more thorough, and to effect a saving of ammunition—not because of its intrinsic value, but because of the limited amount carried by light machines—have gained a similar result by placing on the propeller shaft some cams which permit the discharge of the gun only at the instant when the propeller blade is clear of the muzzle.



Scientific American. 2025

FIG. 5. VEDRINES IN HIS MORANE SINGLE-SEATER MONOPLANE GETTING HIS MACHINE GUN READY FOR AN AERIAL COMBAT

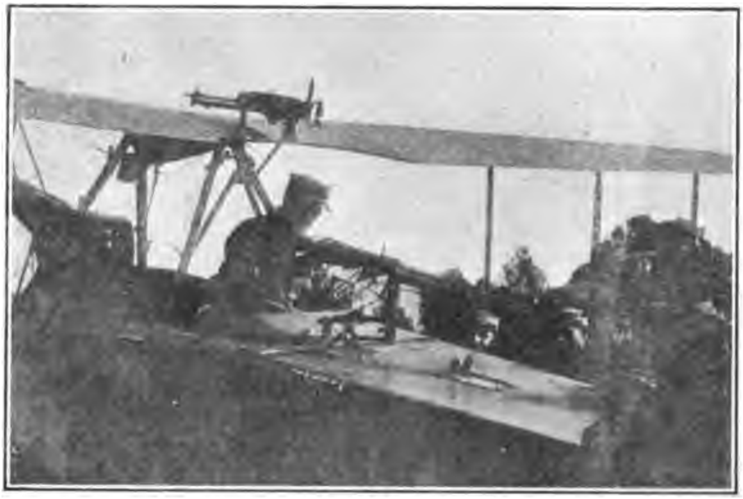
In the early stages of the war the Lewis gun, owing to its lightness, came into almost universal use for mounting on airplanes; but present accounts indicate that the standard English and French types are now being much used.

TERRESTRIAL ANTI-AIRCRAFT GUNS

While the destruction of aircraft can probably be accomplished most effectively by other aircraft, it is not possible for a belligerent, even if most liberally equipped with fighting 'planes, to depend wholly upon them. Numerous occasions will arise when the enemy will be preponderant in the air, even if this condition be only local and temporary.

Bodies of troops must be able to protect themselves, their depots, lines of communication, cities, industrial plants, wharves, docks, and fortifications—as well as prevent reconnaissance and artillery observations. To this end anti-aircraft guns, in great numbers, are essential.

The fire of guns against aircraft presents difficulties that at first sight appear almost insurmountable; and, even after the well nigh unlimited experience the European nations have had, their results with fire against aeroplanes are, considering the enormous volume delivered, almost unbelievably ineffective.



Scientific American. 2026

FIG. 6. VEDRINES EXAMINING THE AUTOMATIC RIFLE OF A GERMAN MERCEDES-AVIATIK TRACTOR AEROPLANE WHICH HE CAPTURED SINGLE-HANDED

The greatest height from which we have definite information that an aircraft has been brought down by gun-fire is 16,000 feet, although the effective height of trajectory of most anti-aircraft guns is much beyond this.

Heights of 10,000 to 12,000 feet are usually considered to give reasonable—though not complete—safety. Effective reconnaissance and observation of fire cannot be accomplished above 4000 to 6000 feet, while bomb-dropping, to give good results, necessitates a descent to a height of 600 to 300 feet. Yet these enterprises are being undertaken daily, and it is notorious that the percentage of casualties among airmen is less than that of artillery, infantry, or cavalry—this notwithstanding the fact that most of the casualties are the result of the natural hazards of the air and combats between aircraft.

The difficulties of fire involve the design of the gun and mount, and the method of fire-direction. As the last is by far the greater, it becomes the controlling factor in determining the solution of the former and will be first considered.

The Problem of Gunnery

The possible speed of aircraft is so great, and the target presented by an airplane is so small, that the problem of hitting one in flight is exceedingly difficult. As an example: Assume an airplane flying 75 miles per hour in the plane of fire, directly toward a point above the gun, and at a constant height of 6000 feet. Seventy-five miles per hour is 2200 yards per minute—or 37 yards per second. This will give a tremendous rate of range change. Such an airplane would approach from a range of 6000 yards to a point directly overhead in 2 minutes and 34 seconds, during which time the airplane would travel 5640 yards and the angle of position would change from 19° to 90°. The foregoing is not at all an extreme case, for airplane speeds today may be assumed to be between 45 and 135 miles per hour. A single range finder will be of little use against such a target, and gun sights can not be kept set continuously.

The correct sight angle of elevation, for firing at a stationary aerial target at any one distance, varies according to the angle of position of the target—from a maximum at, or near, the horizontal to zero at the vertical. This sight angle of elevation varies roughly as the cosine of the angle of position—hence the sight setting for the horizontal range will be nearly correct for a stationary target. However, a stationary target will be seldom encountered—a captive balloon being about the only probable case—and the proper angle of elevation is largely affected by the speed of the target. For example: Assuming the time of flight for 3000 yards to be 5.5 seconds, an airplane traveling 75 miles per hour will travel 201.7 yards during this time. This necessitates a correction for the speed of the target that must be applied to the sight angle of elevation, which becomes largest when the target is flying in the plane of fire—that is, directly toward or away from a point over the gun. For any one distance and speed, this correction varies very nearly as the sine of the angle of position—from a minimum at, or near, the horizontal to a maximum at the vertical. In the case of an aeroplane flying directly toward a point above the gun, it will be seen that these two corrections vary in opposite directions and that they tend to neutralize each other. For any distance there will be a corresponding speed of the target such that one sight setting will be nearly correct for all angles of position. Also, for any given distance, one particular sight elevation can be calculated that will be almost correct for all angles of position of an airplane flying at a given speed.

This tendency of the sight elevation to remain constant with an approaching target, thus prolonging the time during which a given setting may be used without material error, is reversed if the target is retiring, in which case a given sight-setting is approximately correct only at the instant for which it is calculated. Fire upon a retiring target, therefore, affords much less probability of hitting than upon an approaching one. With reference to an aircraft flying at a uniform height and in a right line, we may with advantage consider the problem of gunnery in the six possible phases of presentation:

When flying in a line passing directly over the gun:

1. The phase of approach: during which the distance of the target and the angle of position change at variable rates with neutralizing effect—deflection for lateral travel, none.
2. The phase of tangency: when the target is directly over head, actually a point (but for practicable purposes may be considered as having extension); the distance of the target unchanging; travel in angle of position uniform; deflection for lateral tarvel, none; trajectory a right line.
3. The phase of retirement: the distance of the target and its travel in angle of position change at variable rates with cumulative effect; deflection for lateral travel, none.

When flying on a line passing at a distance from the vertical through the gun:

4. The phase of oblique approach: the same as the phase of direct approach, with the addition of deflection for lateral travel which has a variable rate of change.
5. The phase of tangency: the distance and angle of position are unchanging; the deflection for lateral travel is large, but uniform.
6. The phase of oblique retirement: the same as the phase

of retirement, with the addition of a deflection for lateral travel having a variable rate of change.

These phases may be arranged in the following order as to favorableness of presentation: The phase of tangency above the gun; the phase of tangency on the flank; the phase of direct approach; the phase of diagonal approach; the phase of direct retirement; and, least favorable, the phase of diagonal retirement.

THE TACTICS OF AIRCRAFT

In general and photographic reconnaissance the aircraft will probably fly at a uniform elevation, somewhere between 3000 and 6000 feet. Unusual air conditions may permit them to fly higher or compel them to come lower. Close reconnaissance of a point is made by machines volplaning to a height of a few hundred feet above the point to be observed.

Artillery spotting is carried out by machines flying at a uniform height of 3000 to 6000 feet.

Bomb dropping on cities may be accomplished by machines flying at a great height.

Bomb dropping on selected positions is effected by volplaning to a height of from 1800 to 300 feet, and ascending as they retire. Bomb dropping on troops, accompanied by machine-gun fire from the aircraft, is carried out in the same manner, except that the descent may be even lower. Bomb dropping, machine-gun fire, and close reconnaissance are frequently combined.

Machines in transit over enemy's territory fly at as great heights as they can conveniently attain, 12,000 feet and upward, which gives them practical immunity from gun-fire.

The British airmen—and, presumably, all others—have instructions to "wobble her about a bit" when under fire, alternate dips and rises affecting their regularity both in altitude and in horizontal speed.

FIRE DIRECTION

Unfortunately we have almost no information as to the methods of fire direction now employed by the European armies. Apparently, from the first, the German anti-aircraft fire has been more effective than that of the Allies. This has been repeatedly admitted in Allied publications and is borne out by monthly statements of aircraft losses, in which the

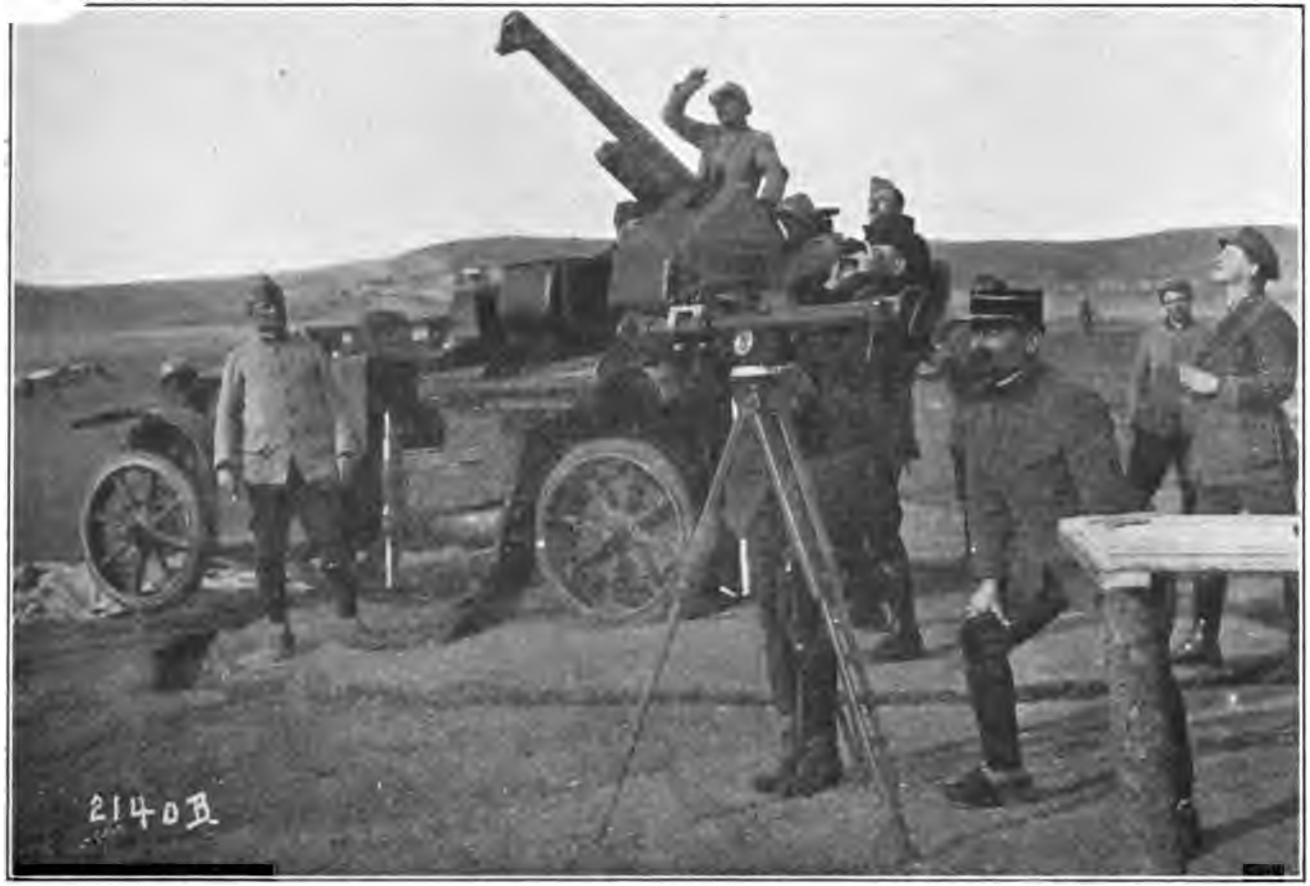


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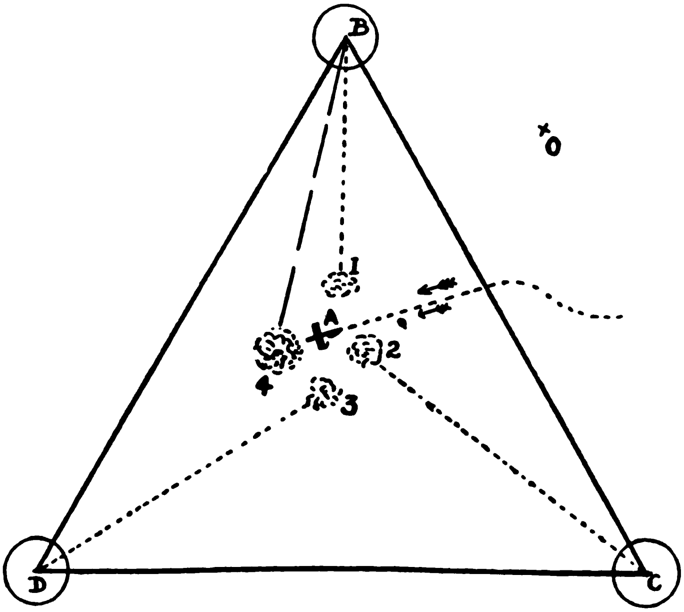
FIG. 7. ANTI-AIRCRAFT GUN MOUNTED ON A MOTOR TRUCK

percentage of Allied machines mentioned as destroyed by terrestrial gun-fire is much larger than that of the Germans.

From photographs of British anti-aircraft batteries we conclude that coincidence range finders, from one to two meters in length, are used for determining distance; and on the trunnions of one of the guns is shown what appears to be a plumb-bob attached to a straight-edge suspended vertically across a horizontal scale, presumably for determining the cosine of the angle of elevation. The guns are in groups of from two to four. Whether flank spotters are made use of, we do not know.

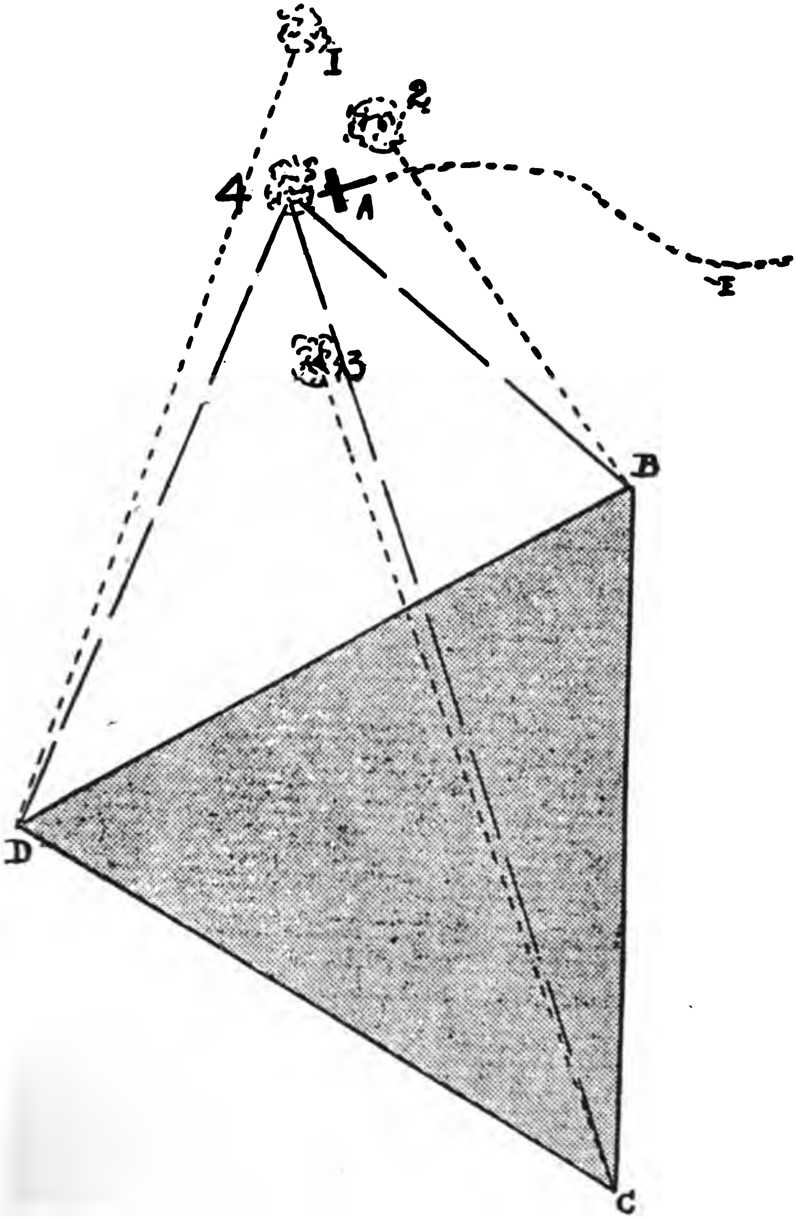


"Aeroplanes and Dirigibles of War," Talbot. 3029

FIG. 8. THE GERMAN METHOD OF PICKING UP THE RANGE WITH ANTI-AIRCRAFT GUN-FIRE (PLAN VIEW)

The following description of the German fire-control system and disposition of guns is given by Talbot in *Aeroplanes and Dirigibles of War*. This is a 1915 publication and probably represents a 1914 situation. Whether a similar system is now in use is, unfortunately, not known.

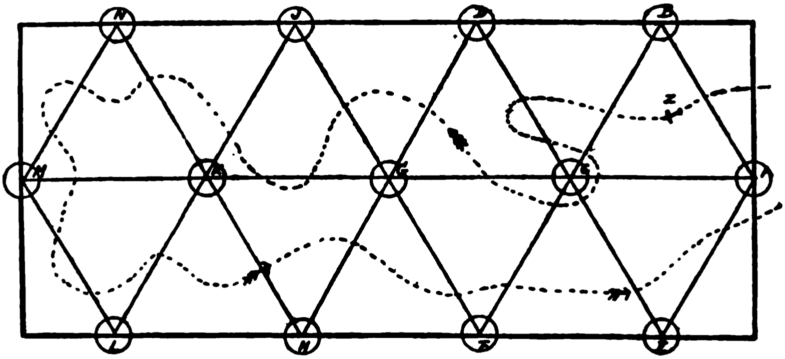
> The favorite German principle of disposing anti-aircraft artillery is to divide the territory to be protected into equilateral triangles, the sides of which have a length of about six miles or less, according to the maximum effective range of the pieces at an elevation of 23½ degrees.
>
> The guns are disposed at the corners of the triangles as indicated. Taking the one triangle as an example, the method of picking up the range may be



"*Aeroplanes and Dirigibles of War*," Talbot. 2029

FIG. 9. THE GERMAN METHOD OF PICKING UP THE RANGE WITH ANTI-AIRCRAFT GUNS (ELEVATION)

explained as follows. The several guns at the corners of the triangle, each of which can be trained through 360 degrees in the horizontal plane, are in telephonic touch with an observer, *O*, stationed some distance away. The airman, *A*, enters the area of the triangle. The observer takes the range and communicates with the gunner, *B*, who fires his weapon. The shell bursts at *1*, emitting a red flame and smoke. The observer notes the altitude and relative position of the explosion with regard to the aircraft, while gunner *B* observes whether the shell has burst to the right or to the left of the objective and corrects accordingly. The observer commands *C* to fire, and another shell is launched which emits a yellow flame and smoke. It bursts at *2*, according to the observer, while gunner *C* also notes whether it is to the right or to the left of the target and corrects accordingly. Now gunner *D* receives the command to fire, and the shell which explodes at *3* throws off a white flame and smoke. Gunner *D* likewise observes whether there is any deviation to the right or left of the target and corrects in a similar manner. From the sum of the three rounds the observer corrects the altitude, completes his calculations, and communicates his instructions for correction to the three gunners, who now merely train their weapons for altitude. The object is to induce the shells hurled from the three corners of the triangle to burst at a common point, *4*, which is considered to be the most critical spot for the aviator. The fire is then practically concentrated from the three weapons upon the apex of a triangular cone, which is held to bring the machine within the danger zone.



"Aeroplanes and Dirigibles of War," Talbot. 2030

FIG. 10. HOW THE FIGHTING ZONE IS DIVIDED INTO TRIANGLES TO SECURE PROTECTION AGAINST AERIAL ATTACK. AN ANTI-AIRCRAFT GUN IS DISPOSED AT EACH CENTER

THE DOTTED LINE INDICATES THE PATH OF THE AEROPLANE, AND THE ARROWS THE DIRECTION OF FLIGHT

This method of finding the range is carried out quickly—two or three seconds being occupied in the task. In the early days of the war the German anti-aircraft artillerymen proved sadly deficient in this work, but practice improved their fire to a marvelous degree, with the result that at the moment it is dangerous for an aviator to essay his task within an altitude of 6000 feet, which is the range of the average anti-aircraft gun.

The country occupied by a belligerent is divided up in this manner into a series of triangles. For instance, a machine entering hostile country from the east, enters the triangle *A-B-C*, and consequently comes within the range of the guns posted at the corners of the triangle. Directly he crosses the line *B-C* and enters the adjacent triangle he passes beyond the range of gun *A*, but comes within the range of the gun posted at *D*, and while within the triangular area is under fire from the guns *B-C-D*. He turns and crosses the line *A-C*, but in so doing enters another triangle *A-C-E*, and comes within range of the gun posted at *E*.

The accompanying diagram, Fig. 10, represents an area of country divided up into such triangles and the position of the guns.

The method just described leaves many points in doubt. Manifestly, as the target would be in a different phase for each gun, the firing data would not be interchangeable except as to the one important element—the altitude of the target. The emplacing of guns singly makes possible the covering of larger areas with a lesser number of guns than would be possible with guns in groups. Furthermore, with guns so distributed, the target must always afford a favorable presentation to some one of the guns. The use of bursting-charges with distinctive colors of flame or smoke—by adjacent guns or groups having a common field of fire, in order that gunners may not be confused in their observation of fire by bursts from other gun-groups—is a manifest advantage.

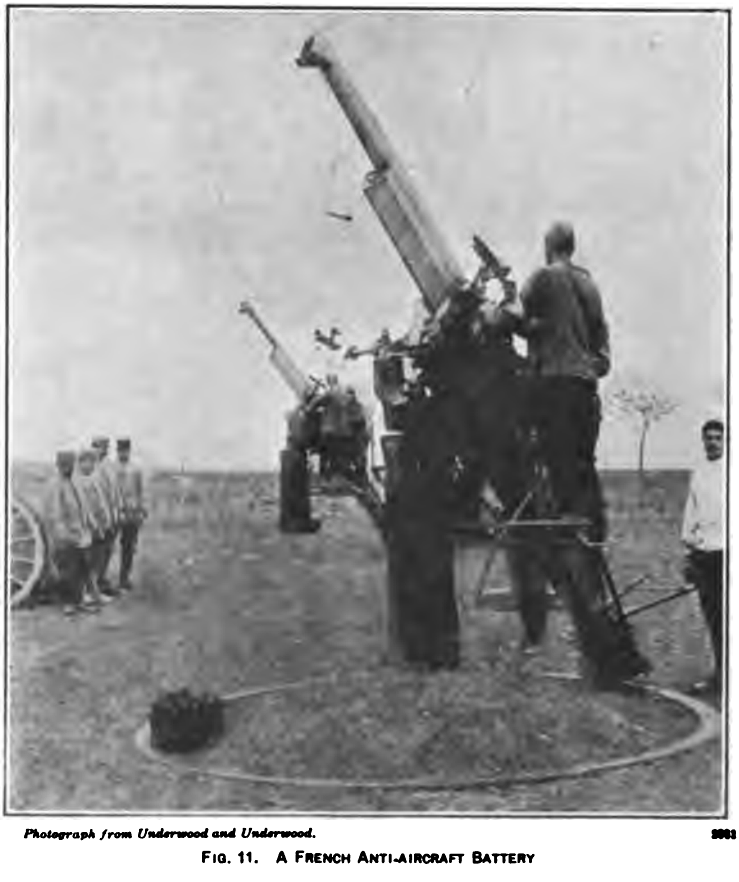
GROUPING OF GUNS

Considering the great speed of aircraft and their ability to move freely in three dimensions, there seems to be small probability of our devising a range-finding system capable of furnishing the gunner with more than approximately correct data. For further direction of fire he must depend upon observation of bursts. Such observations, to be of value, necessitate a very high rate of fire. As automatic guns of sufficient caliber for use beyond point-blank range are not feasible, it will be necessary, in order to attain this high rate of fire, to mount guns in groups of as great numbers as necessary economy and the ability of a battery commander to operate them as a unit will permit.

Major George A. Nugent, Coast Artillery Corps, U. S. Army, has discussed this as follows:

> It is believed that the most effective use of guns requires that they be mounted and used habitually in pairs. Ranging on a rapidly moving target is difficult at best. The experience in the present European War, as far as any reports have been published, seem to indicate that sheaf ranging will give the quickest and most satisfactory results. Where the number of anti-aircraft guns emplaced is small, if the gun defense is to be effective, speed in the adjustment of fire on the target is of great importance, since the length of time the hostile aircraft will be within range ordinarily will be short; and further, it is believed we should be prepared to meet attacks or other operations engaged in by squadrons of two or more craft. Effective

sheaf ranging demands that the guns be located in pairs. If the guns be located in pairs, in order to avoid a dead space over any gun, four guns should be the minimum adopted for any fort. It is not believed that this is an excessive number if an effective defense is to be made. On the other hand, until the number of guns available will permit the mounting of more than two at any fort, it is still believed that two guns should be mounted in pairs.

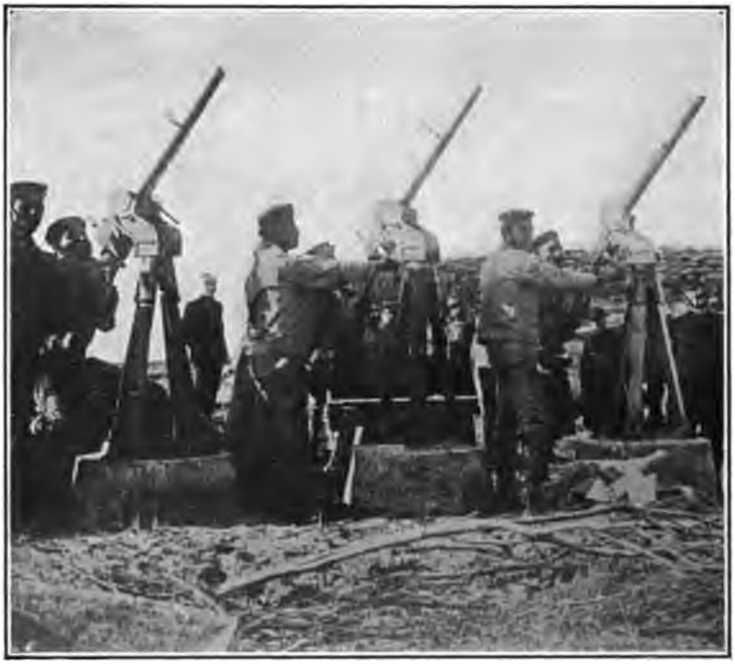


Photograph from Underwood and Underwood. [illegible]

FIG. 11. A FRENCH ANTI-AIRCRAFT BATTERY

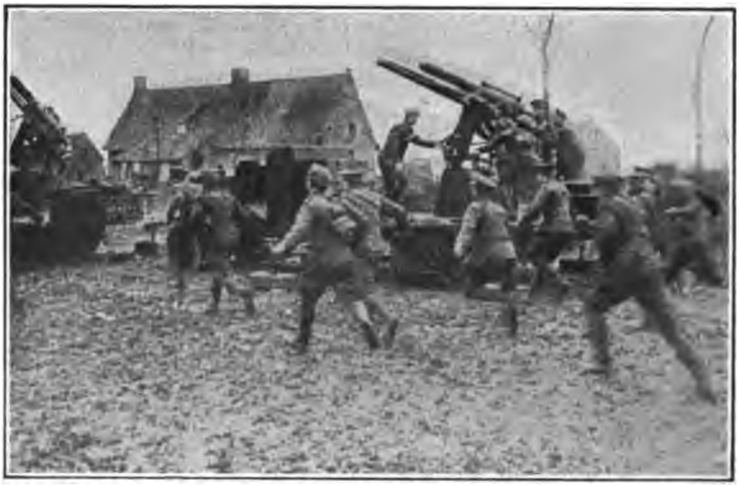
In a very complete article by G. J. N. Carpentier in the *Proceedings, U. S. Naval Institute,* Vol. 42, No. 1, page 183, entitled "The Exterior Ballistic Problem of the Anti-Aircraft Gun," the following conclusion is reached:

> Single shots should never be fired against aircraft; a salvo of four rounds should be a minimum. Double gun mount should be used; the two guns having a permanent angle of divergence of 1° in elevation and 20″ in deflection. The divergence of the two guns, the variation in the aim of the two pointers, the dispersion of the projectiles, and irregularity in the work-



Photograph from Underwood and Underwood. 2032

Fig. 12. An Italian Anti-aircraft Battery



Scientific American. 2033

Fig. 13. Running to Man the Anti-aircraft Guns

ing of the time fuses, would insure the bursting of the four projectiles in a space in which the aircraft will be more exposed than if 12 rounds were fired successively at it.

The arguments which lead us to conclude that a group of two guns is more effective than two guns mounted singly, may be indefinitely extended to groups of four, six, or eight—up to the point where unity of control is lost. The question will be decided practically by the area which must be defended and the number of guns available. We may, however, adopt as working hypotheses the principles that it is better to leave dead space than to emplace guns singly, and that the grouping of guns of different ballistic characteristics is worse than useless. Machine and automatic guns for use at short—practically point-blank—ranges gain nothing by being grouped.

Fire Control

The arguments for gun-grouping lead inevitably to the conclusion that only one battery at a time should fire upon a given target, unless provided with projectiles having distinctive bursts. Fire control will thus be a necessity. This may be accomplished either from a central fire-control station or by pre-arrangement as to sector assignment. To avoid fatal delay the latter will probably be the more practical arrangement, although a combination of both may be found advisable.

Fire Direction for Guns in Groups

For guns in groups the method of fire direction given by Talbot is inapplicable; and sheaf-ranging—except for tangential targets—offers little prospect of success, for the reason that by the time a bracket has been obtained all firing data will have changed.

The most hopeful suggestion offered appears to be the use of a system of zones, to be accomplished by setting all fuses beforehand for a series of distances; as, for instance, 1000, 1500, 2000 yards, etc. Each fuse-setting would constitute a zone nearly hemispherical in shape: having its center at the gun; its inner radius the distance for which the fuse is set; and the thickness of the wall being the effective range of shell-fragments or shrapnel beyond the point of burst. The several hemispherical zones would be concentric, and any target passing through the field of fire must pass through them successively. Fire is opened in the zone ahead of the aircraft and is continued until a burst near or in rear of the target is observed, when the zone is changed to one ahead, whereupon the process is repeated. Flank spotters determine when the target has passed through the zone and a change of fuse-setting is necessary. The range section determine, as frequently as possible, the approximate distance for the selection of zones and the altitude at which the target is flying.

Such a method of establishing successive curtains of fire gives assurance that at some point in each zone the firing data will be correct for fuse setting and range.

On the other hand, an attempt to determine and set the range for each shot will very probably result in an error persistently repeated throughout the course of the target in the field of fire.

INSTRUMENTS FOR FIRE DIRECTION

It is manifest that instruments for fire direction must be simple in operation. The refinements introduced in artillery fire direction at fixed or slow moving targets must be omitted.

The instruments employed in Europe—those of which we have knowledge—are self-contained range finders one to two meters in length, vertical-angle measuring instruments, and a graphic device for determining the range and vertical height from the distance and the position-angle. In one report, mention is made of a long horizontal base and a plotting board. It may be that this is only used against captive balloons.

A number of ingenious sights have been devised, among which are the Grubbs, of Dublin; Schneider, of Le Creussot; Fr. Krupp, of Essen; and the Goetz. In general these sights have eye pieces turned at right angles to the line of sight, and so mounted that the axis of the eyepiece coincides with the axis of the gun trunnions. No movement of the gunner's eye is necessitated by a change in the elevation of the piece. The Grubbs and Schneider have fixed, vertical, telescopic tubes with an objective mirror actuated by the movements of the gun. The Krupp is partly automatic and, by means of a series of cams (the sight having been set for distance), the elevation and depression of the gun adjusts for changes in sight elevation due to changes in the angle of position. Of the Goetz we know practically nothing.

ANTI-AIRCRAFT GUNS AND MOUNTS

The supreme difficulty of the anti-aircraft gunner is fire direction. The reducing of these difficulties must be the prime object of the gun and mount designer.

In examining the difficulties of fire direction we find their sources in two elements: The time of flight, and the curve of the trajectory. With these elements reduced to zero, hitting would be assured; and with each increase in their value, the probability of hitting falls off in approximately a geometric ratio. The highest velocity attainable between gun and target is a fundamental requisite.

As we are compelled to admit that our fire direction involves large elements of chance and that our percentage of probable hits is small, while favorable presentation of the target will be brief, we must demand guns capable of giving very rapid fire for short periods.

Owing to the great angular speed of the target, the gun must be designed to permit facility in pointing.

The field of fire includes the entire hemisphere above the horizontal plane, but mechanical considerations may compel us to omit an inverted cone of about 20° directly above the gun. In doing this we are depriving ourselves of the opportunity of attack in the most favorable plane of presentation. Elevations below 15° will probably be but little used against aircraft and, aside from the advantage of covering this field in emergency against land attack, lower elevations will not be required.

Many—if not all—anti-aircraft guns must be mobile to the extent of accompanying troops and making reasonably prompt changes of position.

The gun-designer is thus confronted with five fundamental considerations, involving a number of conflicting requirements which must be compromised, viz.:

High velocity from gun to target.
Rapidity of fire.
Facility in pointing.
Hemispherical field of fire.
Mobility of mount.

Sustained velocity requires a high initial velocity and a considerable weight of projectile, necessitating relatively heavy guns and mounts. Rapidity of fire, facility of pointing, approach to a hemispherical field of fire, and mobility of mount, are all most readily attained with light guns.

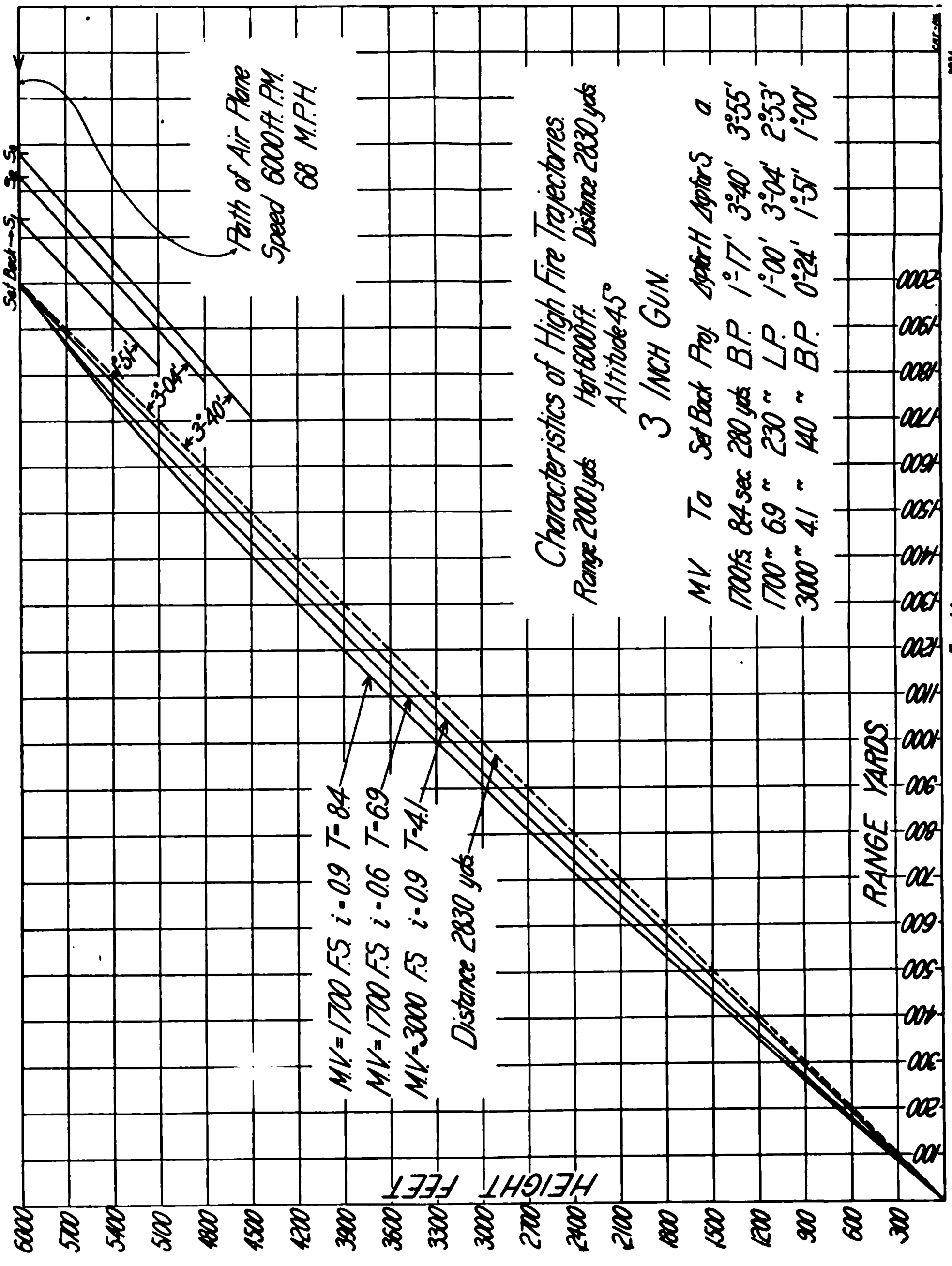
High muzzle velocity is easily obtained with light projectiles, but sustained velocity requires weight and a low coefficient of form for the projectile. Therefore, if it meets the other requirements, we may regard that gun as the most satisfactory which gives us the shortest time of flight through the ranges which we regard as the most important.

Captain A. L. Rhoades, Coast Artillery Corps, U. S. Army, has prepared the attached chart for a distance of 2830 yards, elevation 6000 feet, and an angle of position of 45°. On this chart are drawn three trajectories for the 3-inch gun:

The 1700 f. s. blunt projectile.
The 1700 f. s. sharp projectile.
The 3000 f. s. blunt projectile.

These trajectories are worthy of careful study. The chief source of error in fire is due to movement of the target during the time of flight. Any failure to properly judge the speed of target will result in an error in the placing of the shot, and it is manifest that the actual error will be directly proportional to the time of flight. Particular attention is drawn to the advantages of the long-point projectile, even at this comparatively short range; and this advantage is one that increases very rapidly with distance. Mechanical reasons may make high velocities impossible with mobile mounts; but good ballistic form for projectiles can be had and must be insisted upon. In our service, time fuses have not been successfully used in projectiles below 3-inch: this practically fixes the inferior limits of caliber. The burst must be readily visible: this may force us to larger calibers for use against targets at great heights.

For what heights of targets should our guns be designed? As we have seen, several forms of attack are now made from very low altitudes. Even 3-inch guns cannot be trained on targets having the angular velocity this entails. Such attacks are particularly menacing and can be met only by high-power machine-guns using armor-piercing bullets, or by one- to two-pounder automatics. Offensive operations against terrestrial objects cannot be carried out from above 8000 feet, except the bombing of cities. Owing to the very doubtful results to be attained, and the endangering of friends from falling projectiles, it is questionable whether attacks should be made on aircraft outside the zone of their possible offensive activity. Therefore we may regard the 3-inch gun tentatively as sufficient for general purposes. The defense of cities must be con-



M.V.	Ta	Set Back	Proj.	Δa for H	Δa for S	a
1700 f.s.	8.4 sec.	280 yds.	B.P.	1°17'	3°40'	3°55'
1700 "	6.9 "	230 "	L.P.	1°00'	3°04'	2°53'
3000 "	4.1 "	140 "	B.P.	0°24'	1°51'	1°00'

FIG. 14.

sidered as a special case. From a purely military standpoint it is probably true that aircraft beyond the reach of 3-inch guns had best be left to our battle 'planes. Popular clamor—as evidenced in England—will not permit this, and we must provide guns of larger caliber, on fixed mounts, for this purpose.

Although the 3-inch anti-aircraft gun is most generally used abroad, the fact that the French are using 4-inch, the Germans 5-inch, and the British 6-inch, should prevent our forming a too hasty and definite a conclusion on the subject of caliber. The occasion for the British 6-inch is apparent. These were mounted on monitors in harbors of the east coast for use against Zeppelins in transit at great height. We are not informed that they were ever effective, while we know that the 3-inch have proven so against Zeppelins on several occasions.

The relative advantages of fixed and mobile mounts may be summarized as follows:

Fixed Mounts

a. Permit the use of heavier guns and higher velocities.

b. Increase the accuracy of fire.

Mobile Mounts

a. Permit a more effective tactical use of the guns.

b. Allow greater latitude in the location of the guns.

c. Give assurance that the position of the guns will not be known to the enemy in advance, and they may be frequently moved.

d. Permit the withdrawal of the guns more easily from the zone of hostile fire.

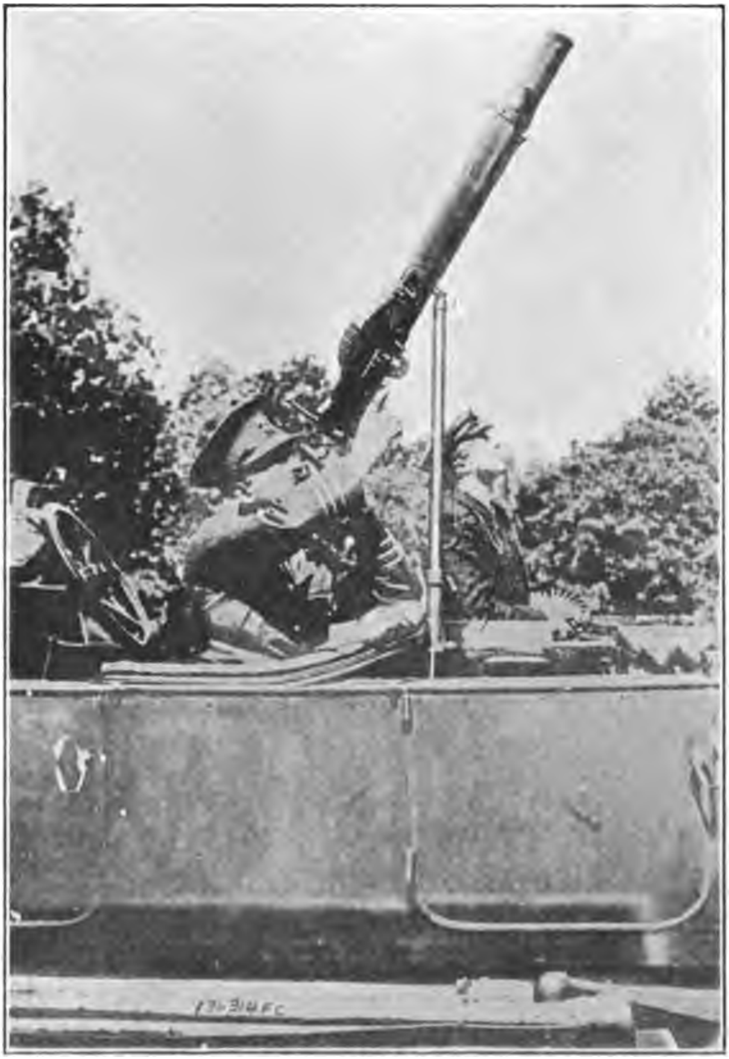
e. Allow the guns to be cared for and guarded much more economically and effectively in time of peace.

Prior to the outbreak of the war in Europe we probably had fairly complete information as to anti-aircraft artillery designed abroad. Since that time we have received but scraps of information as to the progress which has been made.

The British—as it would seem very wisely, in view of the importance of rapid fire and the difficulties of hand-loading at high angles—attribute great value to the automatic and semi-automatic features. Captain Frank T. Hines, Coast Artillery Corps, U. S. Army, describes, among others, the following British and German Guns which indicate the possibilities in this direction.

The Vickers Company, Limited, make a specialty of the development of anti-aircraft ordnance and have produced many ingenious contrivances.

This company has produced fully-automatic guns of various calibers from rifle caliber up to 2-pdrs., capable of a rate of fire of from 500 rounds per minute, with the rifle caliber, to 200 rounds per minute for the 2-pdr. These guns fire with equal facility from 10° depression to 80° elevation.



Photograph from Underwood and Underwood. 2035

FIG. 15. A LEWIS GUN MOUNTED ON AN AUTOMOBILE AND BEING FIRED AT AN AIRPLANE

A special feature of the pedestal mount produced by the Vickers is that not only can the gun be fired at practically all angles of elevation, but that the pivot, around which the gun is traversed, is always in the vertical position.

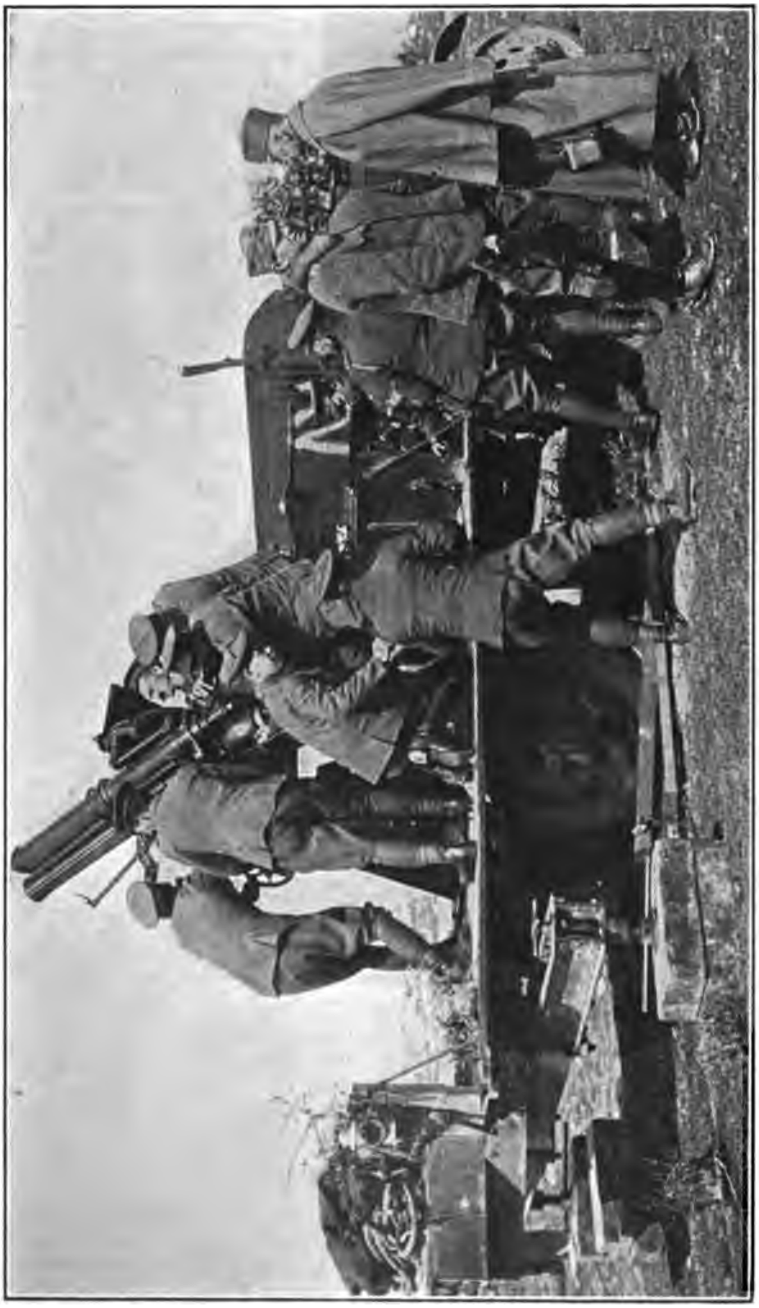


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FIG. 16. IN ACTION: A BRITISH ANTI-AIRCRAFT GUN ON A MOTOR TRUCK

[illegible]

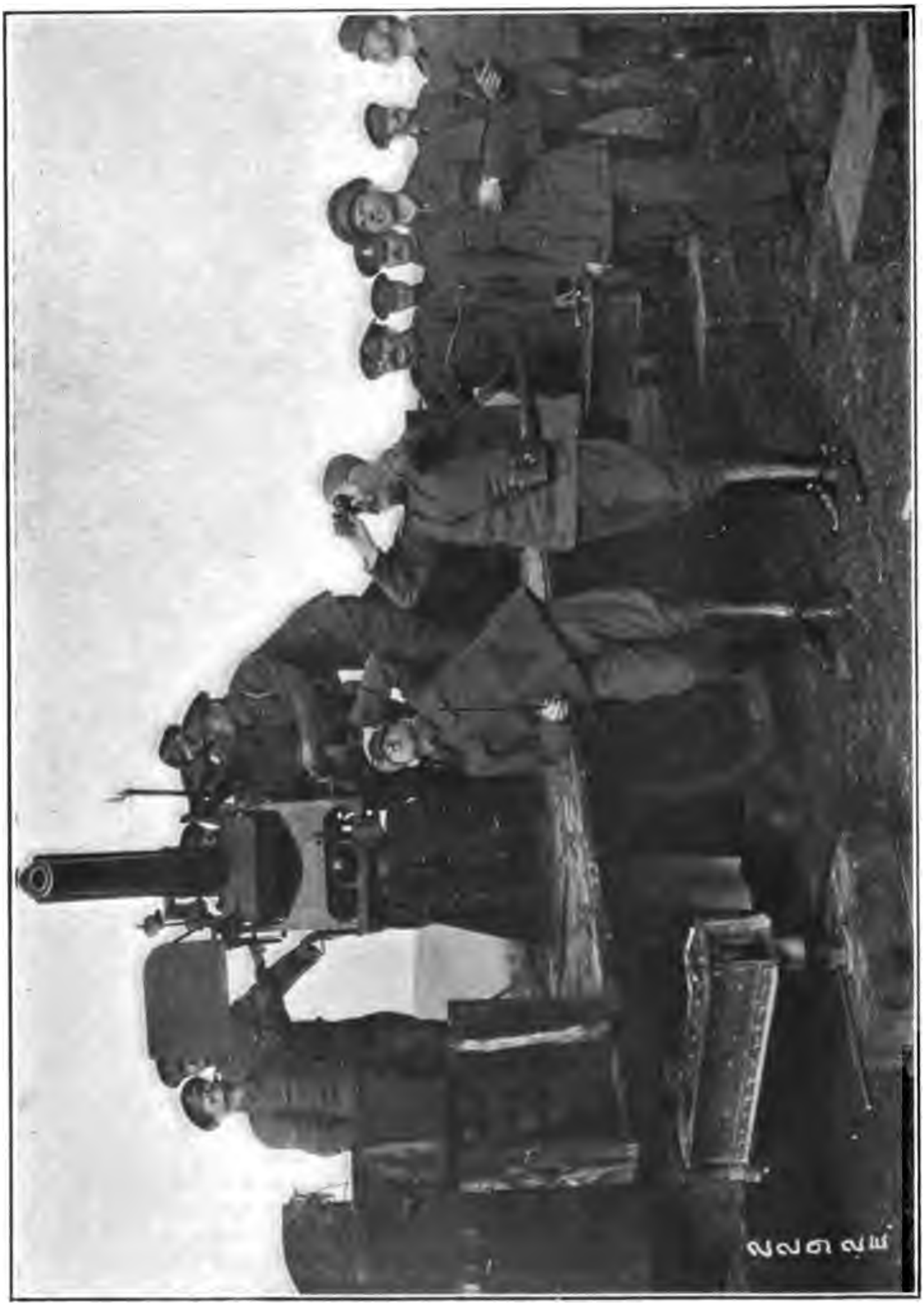

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Fig. 17. A British Anti-aircraft Gun on a Motor Truck

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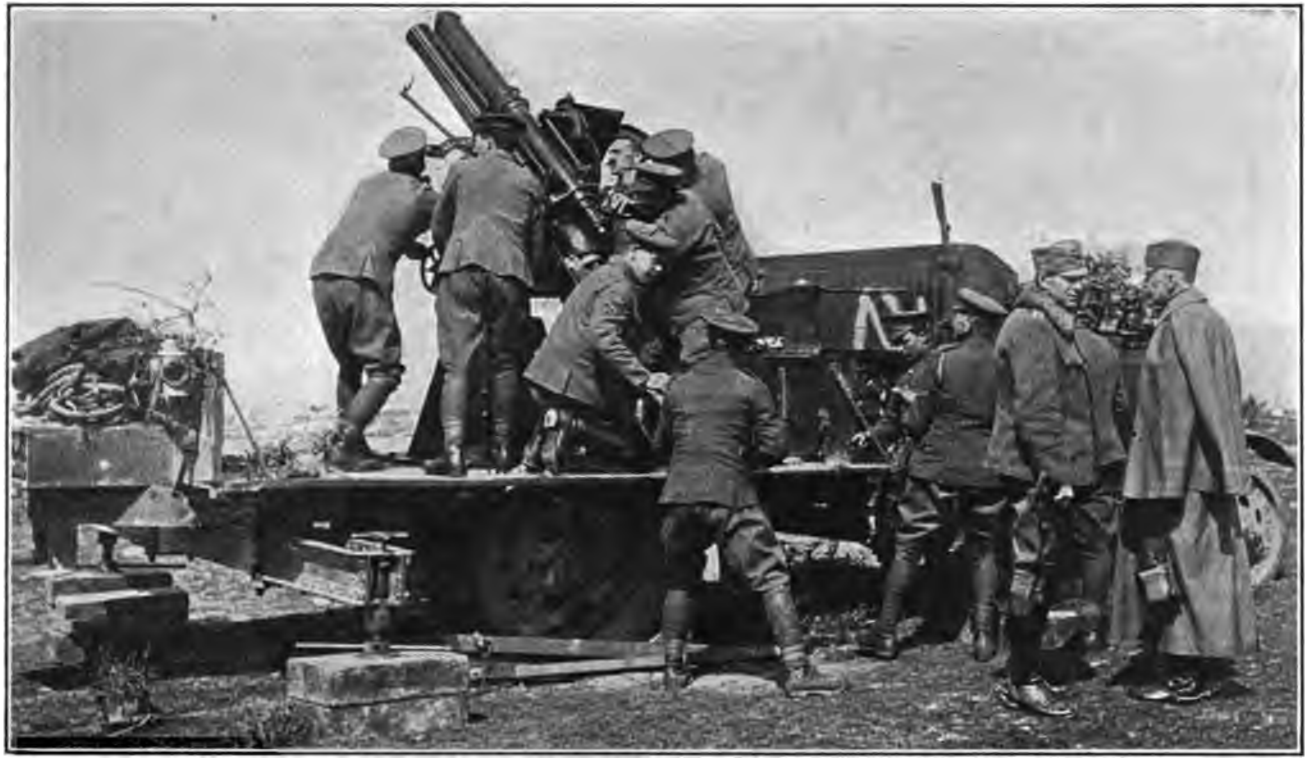

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FIG. 16. IN ACTION: A BRITISH ANTI-AIRCRAFT GUN ON A MOTOR TRUCK

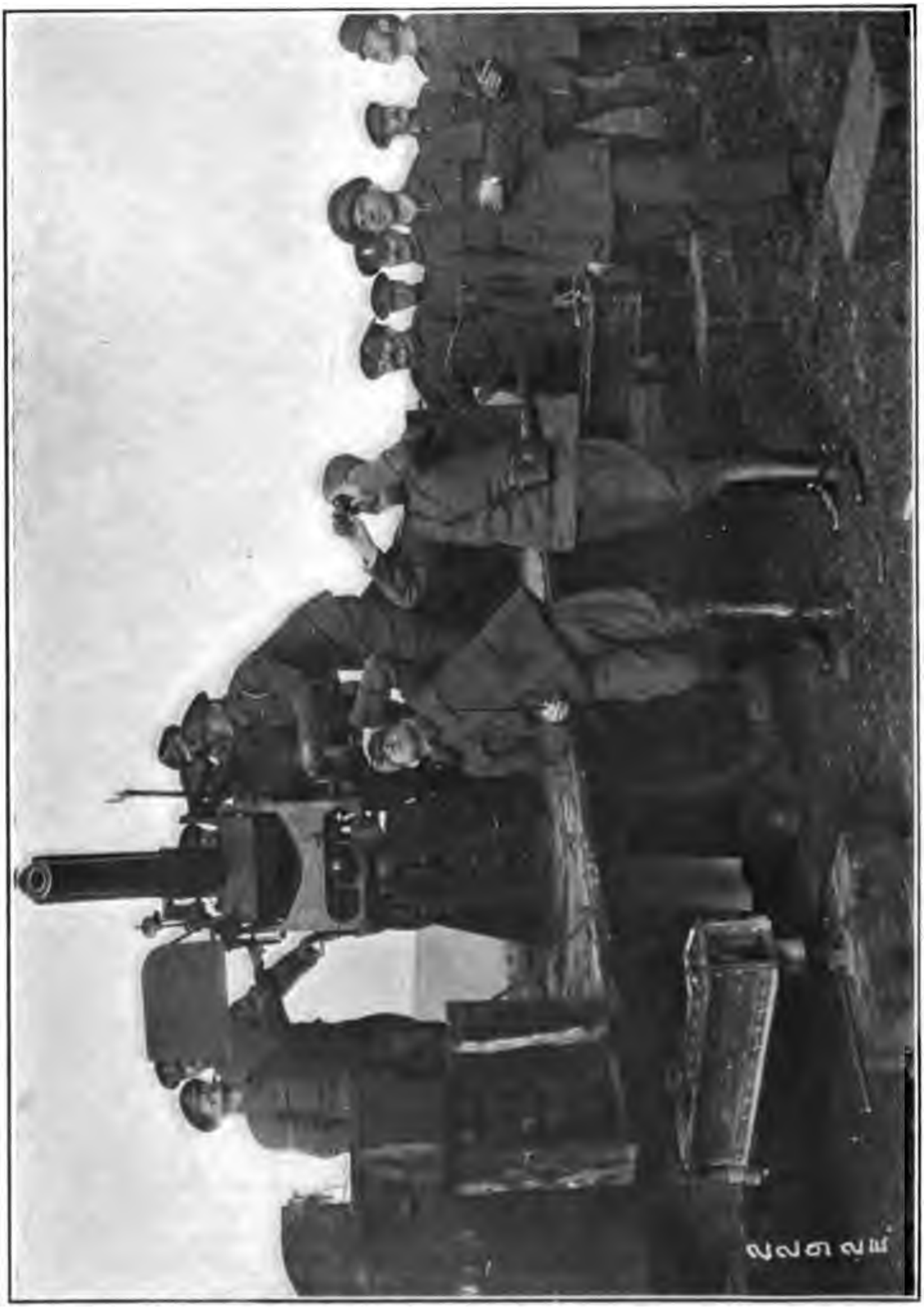

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Fig. 17. A British Anti-aircraft Gun on a Motor Truck

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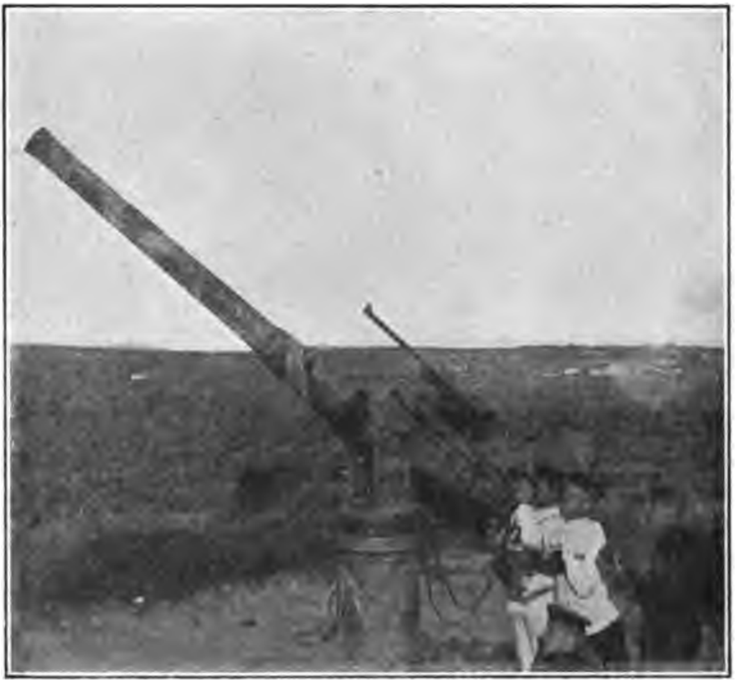
At stated intervals either fused projectiles or smoke-producing projectiles are inserted, and this makes it possible to detect with more certainty the effectiveness, or otherwise, of the gun-laying, so that a practically constant stream of ammunition may be played on the aircraft which is being attacked.

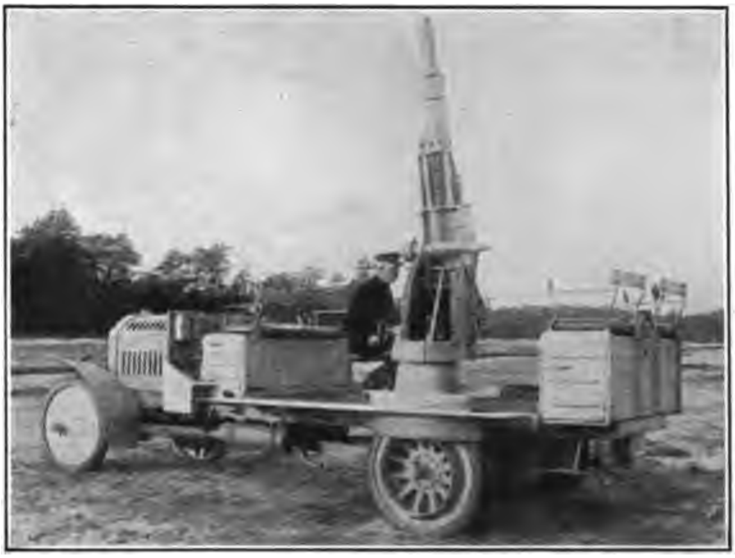
The Vickers Company has also produced a larger caliber, semi-automatic gun, for anti-aircraft use. This gun is a 3-inch, 45-caliber, semi-automatic gun, mounted on a high-angle pedestal mounting, designed so that it may be used either as an anti-torpedo gun or as an anti-aircraft weapon. The breech action consists of a longitudinal sliding block, and is semi-automatic; that is, the breech is opened during the run-out of the gun after firing, the empty cartridge case is ejected, and the breech is automatically closed as the case is inserted. The weight of the projectile is 10.8 lbs.; the muzzle velocity, 2700 f. s. The mounting is designed so that the gun can be fired at all angles from several degrees depression to 80° elevation. The elevating and traversing hand wheels are conveniently situated; the former on the left-hand side of the mounting, and the latter on the right-hand side. The sight is cross-connected; and the eyepieces of the telescope, and the general construction of the sight, are so arranged with respect to position and detail, that they are equally convenient for the gun-layers at all angles of elevation, and no trouble whatever is experienced in following the target with the arrangement provided.



Photograph from Underwood and Underwood. 2038

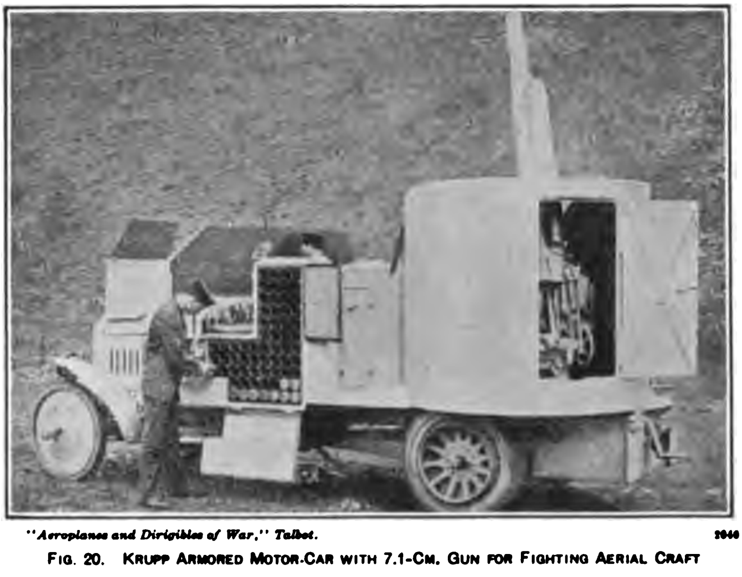
FIG. 18. AN ANTI-AIRCRAFT GUN AT GALLIPOLI

The Vickers-adjustable-tripod-mounting for the smaller calibers of anti-aircraft weapons has proved to be a very convenient mount.



"Aeroplanes and Dirigibles of War," Talbot. **2039**

FIG. 19. "ARCHIBALD," THE GERMAN MOTOR MOUNTED ANTI-AIRCRAFT GUN



"Aeroplanes and Dirigibles of War," Talbot. **2040**

FIG. 20. KRUPP ARMORED MOTOR-CAR WITH 7.1-CM. GUN FOR FIGHTING AERIAL CRAFT

The *Naval Annual, 1914*, states that the Krupps had perfected, up to that time, three patterns of anti-aircraft guns—a 12-pdr., of 45 calibers, and a 3.4-inch in 35 and 45 caliber lengths. A larger gun, 4.1-inch, was

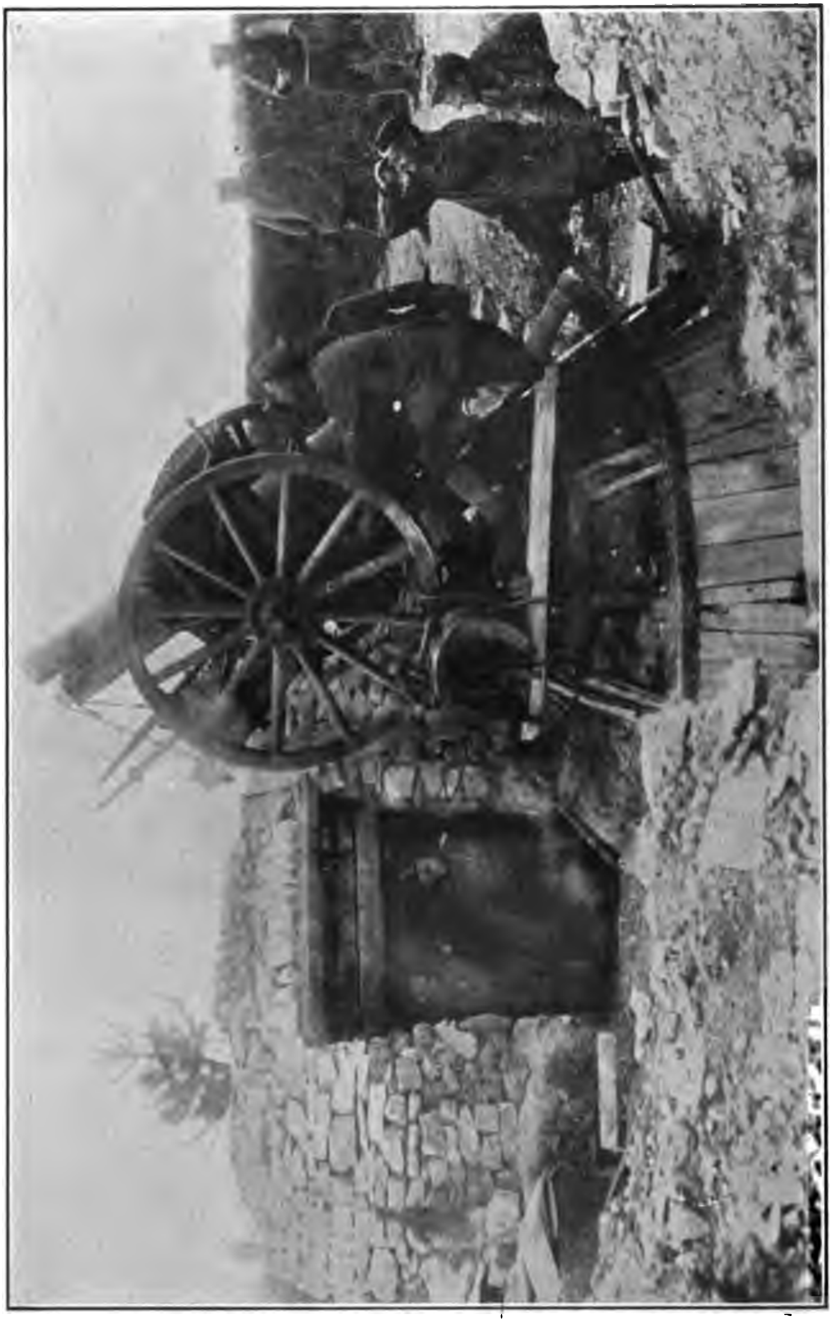


FIG. 21. AN IMPROVISED ANTI-AIRCRAFT WEAPON

Photograph from Underwood and Underwood.

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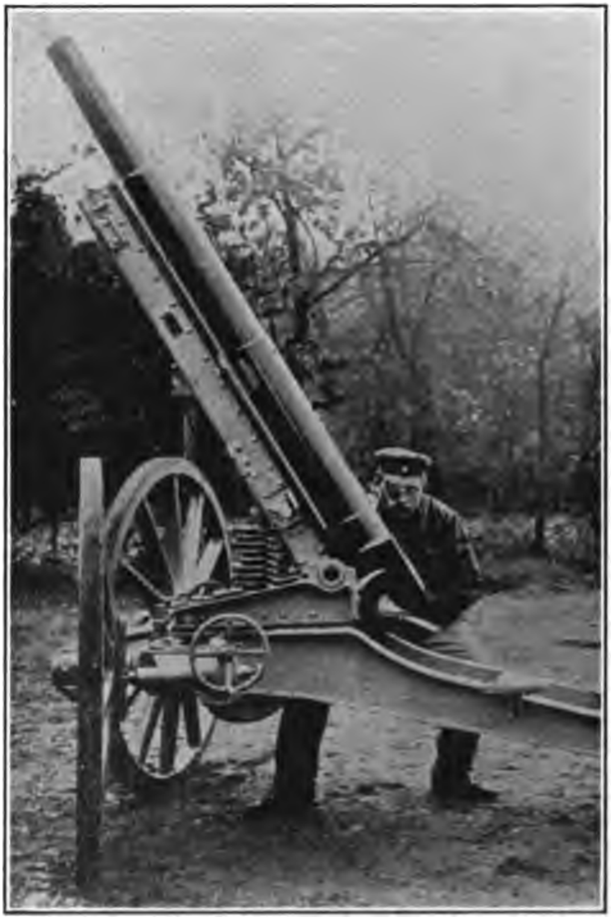
developed for coast work. The angle of elevation is 80°, or, with a shield mounting, 60°. The carriage permits of all-around fire. The projectile, which weighs 21 lbs., has an initial velocity of 2067 feet in the shorter gun—2628 feet in the larger—and from 20 to 25 rounds per minute can be fired. The 35-caliber gun weighs 6800 lbs.; the larger gun, 11,500 lbs.; and the shield, which has a maximum thickness of 2 inches, weighs 4700 lbs.



"Aeroplanes and Dirigibles of War," Talbot. 3043

FIG. 22. THE LATEST KRUPP ANTI-AIRCRAFT GUN, SHOWING NOVEL DISPOSITION OF WHEELS

It is understood the Germans are now using a 4.1-inch anti-aircraft, Krupp gun 45 calibers long, which sends a projectile weighing 34 lbs., with a muzzle velocity of 2640 f.s., to a height of 13,200 feet. It can be fired at the rate of 15 rounds per minute. The shrapnel shell which it fires is said to burst into 625 fragments. Guns of this type, as well as those of 5-inch, are used in the defenses at Ostend.

MILITARY AND NAVAL CO-OPERATION

By Brigadier-General JOHN W. RUCKMAN, U. S. Army

The present demands for Naval and Military Co-operation rank among the highest considerations affecting success in war. The questions which proper co-operation presents to military students and commanders have greater range and scope than any that refer to the services singly. The solution of problems emanating from the demands for teamwork must be based upon careful study and analysis of existing conditions by the highest military authority, which, for short, may be denominated a *Great General Staff*. It is understood that this staff will be composed of both army and navy officers who will have in their hands the preparation of the general strategical plans for the prosecution of war. When this body of men has turned over its plans to the proper authority for execution, it falls to the various commanders of both services to play their respective rôles not only with energy and skill, but with loyalty to the end in view—to the exclusion of local or personal gains—and in a broad and generous spirit of co-operation with all commands concerned. These ideas appear to express self-evident facts and will appeal to all minds familiar with the requirements of teamwork in great undertakings. Notwithstanding the force of these words, the necessary spirit has not always been present; and it is surprising to see how men, who appeared to be thoroughly loyal to a cause, have permitted their prejudices or jealousies to interfere with harmonious procedure, and bring on disaster.

It is the purpose of the following remarks to present some of these cases, lay bare the causes of the misunderstandings, study the same, and suggest lines of action pursuant to which discordant views will be reduced or obviated.

History teems with examples where desirable teamwork was lacking and where neither commander would recede or yield at all in his misconceptions, let us say, of the requirements of the existing situation, because he was too ignorant to recognize his own deficiencies and too obstinate to be influenced by pertinent considerations which he could not appreciate. In fact there have been so many cases where disaster came from inharmonious conditions—due to ignorance, jealousy, misconception, or other improper motives—that a brief review of a few of the more significant examples will emphasize the seriousness of the subject.

Distrust and lack of agreement amongst commanders of different services, in movements where both are concerned and have rôles to play, will continue to create havoc in our operations—unless some status can be established for them, through which all will be able to see the end in view and to strive for the same with all their power and under a common impulse and bond of co-operation. The evil results of lack of harmony will be greater in the future than they have been in the past; greater stakes will be involved.

In the old days conditions were different from those now existing and from those which will exist in the future. Past demands for efficiency have not been so severe as now; neglect of harmony and teamwork, by which efficiency may be secured, is no longer tolerated in industrial enterprises; and the coming age, with its higher organizations and administration, will not accept independent action by different commanders, where united effort should obtain.

It is only within recent years that the causes of failure of combined military expeditions have been investigated; otherwise it would seem that some of the failures of early times would not have been repeated over and over again. Historical study of the causes in such situations and an honest endeavor on the part of all to eliminate them for the future will remove, to a large extent, further embarrassment in this respect.

Historical Review

COMBINED OVER-SEA EXPEDITIONS

Time and space will permit us to mention but a few of the most important illustrations of the subject in hand. There are so many such cases that might be mentioned that a complete survey of the field is impossible. The few here presented will indicate the seat of the trouble and suggest an outline of what will appear to be the proper policy to obviate the trouble.

The Turkish Expedition Against Malta in 1565

The failure of this expedition was due, mainly, to the quarrels between Mustapha, the commanding general, and Piali, the admiral. It appears that both blundered and were to blame. The historian of the Knights of Malta writes: "Each was more intent upon depriving his colleague of the honor of success than of carrying on the main objects of the expedition, and each felt that if he were not to be the principal actor at the capture of the Island he would rather that the attempt were a failure than that the other should reap the fruits of success."

The Capture of Cartagena by the French in 1697

De Pointis was a commodore in the French Navy and wished to conduct a privateering expedition to the West Indies. Du Casse was governor of Hayti and had orders to assist the former with the resources of the island. He had difficulty in collecting and holding the colonists and filibusters in idleness awaiting the delayed arrival of De Pointis. The latter was angry because more men were not collected, in spite of the explanation of Du Casse that the island could not be stripped of all defense. About 1200 men were available. De Pointis became so overbearing to them that a mutiny arose which no one but Du Casse could quell. Du Casse decided, in the interests of these men, to go with the expedition. He was thoroughly conversant with the conditions in the West Indies and would have been a good adviser to De Pointis; but the latter ignored him and gave him no command, although he was a naval officer and next in rank to De Pointis. Du Casse went as a volunteer. Although disagreements continued throughout the enterprise, Cartagena was captured.

Penn's and Venables' Expedition to the West Indies in 1655

Penn was in command of the fleet and Venables was in command of the land forces. The expedition was dispatched to the West Indies to wrest them from Spain. Bad blood existed between the two commanders before the expedition was made up, and three commissioners were sent with them to maintain harmony. Before he sailed, Penn was cautioned by the highest naval authority as to the necessity for maintaining good feeling and cordial relations with the military commander. Good relations did appear to exist for a time, but finally the old jealousies broke out anew as the expedition approached its objective and the moment for action arrived. Venables charged Penn with grudging his soldiers food, and Penn commented on the other's operations in a caustic manner. The expedition ended in disaster.

The Armada Sent to Cadiz in 1702

A landing was effected and some damage done to the enemy, but the failure of the effort was mainly due to the quarrels between the generals and the admirals. Colonel Stanhope, a member of the expedition, writes: "We are not only divided, sea against land, but land against land, and sea against sea."

Expedition to Cartagena, Colombia, in 1741

In these operations Admiral Vernon commanded the fleet and General Wentworth the land forces. Here there was no excuse for bitterness in rivalry and no justification for jealousy; yet the affair was mismanaged from the outset and the untoward discussions between the commanders were the principal cause of miscarriage. Lord Mahon says: "Vernon would bear no colleague and Wentworth no master. Wentworth complained that Vernon was slow in landing tents, stores, and artillery for the troops, and Vernon that the other had delayed longer than necessary and had failed to cut off the garrison from its source of supplies in the country. An attempt to storm one of the works failed miserably through mismanagement. In this affair Vernon's behavior was not incompatible with a malicious pleasure in the failure of an enterprise not conducted by himself." The entire campaign ended in a disastrous failure.

The Campaign Against Louisbourg

In this campaign Boscawen and Wolfe, admiral and general, worked together in the closest harmony in that brilliant attack upon Louisbourg by which the place was captured. The same good feeling and harmony existed between the two commanders during the following year which ended in British control of the St. Lawrence Valley.

Attack on Havana in 1762, Etc.

General Moncton and Admiral Rodney, a few years after the capture of Louisbourg, worked in close harmony at Martinique, winning notable victories in conjunction there.

In 1762 the military and naval forces attacked and reduced Havana, operating throughout in cordial co-operation.

In the war which ended with the independence of the

American Colonies, the two services afforded each other the loyal support under the most difficult circumstances; even in some cases where misunderstandings occurred.

La Bourdonnais and Dupleix in India

The former, on his arrival in India, perceived that French sovereignty in the East must rest upon sea power, and he took active steps to prepare for the decisive struggle with England which he foresaw would come. When the conflict commenced, he found himself confronted at every turn by unexpected difficulties emanating from the suspicion, jealousy, and obstructive methods of his military chief—Dupleix. Finally the crisis came and La Bourdonnais returned to his native land. Under the genius of Clive and British sea-power, French dreams of supremacy in India vanished forever.

A few years later Count Lally, the French governor and commander-in-chief, quarrelled with D'Aché, the admiral, who finally left the government in the lurch—and British sea-power settled the fate of India. Thus was lack of co-operation a dominant factor in the struggle for ascendancy in India. With cordiality and sincere co-operation between the military and naval commanders the result in India might have been different.

Clinton's Proposed Attack Upon Rochambeau at Newport, Rhode Island, in 1780

General Clinton, commanding the British forces in New York, desired to attack Rochambeau at Newport, where the latter had landed 5000 men. Admiral Arbuthnot, commanding the British naval forces, either could not or would not provide the required transports for the expedition. The result was bad feeling and delay until Rochambeau had fortified his positions and it was considered useless to attack. The scheme was abandoned.

Admiral Jervis and General Grey in the West Indies in 1793

Jervis and Grey executed a successful campaign in the West Indies in which effective co-operation continued throughout. Later, when the admiral organized an expedition, he ordered Commodore Duckworth, commanding the escorting squadron, to join in any other plan of attack or defense which the general might suggest.

Operations Against Corsica

In these operations trouble existed between Sir John Moore and Nelson, who distrusted the former. It is reported that the latter was jealous of the army and wished Moore a hundred leagues away. In the same campaign Hood claimed the right to command the military forces, thereby increasing the friction already existing.

Wellington and the Fleet in the Peninsula

Wellington always acknowledged in the handsomest manner, and on the spot, the valuable services of naval officers. His quarrel was not with the navy, but with the Admiralty. He complained bitterly of his over-sea lines of communications being cut by the enemy through failure of the navy to protect them, and his complaints led to a bitter controversy.

The Plattsburg Campaign of 1814

After two years of ineffective fighting, General Prevost, British commander, having been reinforced by troops from home and urged to act with vigor, undertook to advance along the western shore of Lake Champlain. A flotilla to co-operate with the army was being prepared. The commander thereof, being goaded on by the general, finally started before the flotilla was ready for service. The army of Prevost was to co-operate with the fleet, but failed to do so. The latter was completely and disastrously defeated and the enterprise was abandoned. The military commander is blamed for the result.

THE ATTACK OF FLEETS BY LAND FORCES

The foregoing illustrations of joint army and navy operations relate principally to cases where the army depended upon the navy for transportation and escort and such assistance as could be given by the latter in active field or siege operations. History furnishes numerous examples of another kind of combined operations in which the hostile fleet has been restricted to its own harbors or waters and could not be reached by the opposing fleet. Under such circumstances it became necessary to attack the former with land forces. A few of the more prominent expeditions of this class will elucidate the subject.

The Capture of Wei-Hai-Wei by the Japanese in 1895

The Japanese having conquered Corea, and wishing to continue operations, contemplated a campaign against Peking. Before such a campaign could be undertaken, however, they were compelled to dispose of the Chinese fleet then based upon the fortified place of Wei-Hai-Wei, which was directly on their line of communications in the proposed campaign. The fleet could not accomplish the task without the assistance of a land army which was called to the assistance of the fleet. The army landed a few miles from the objective, marched upon it, and made its attack in close co-operation with the fleet. The land and naval forces worked in harmony until the place was captured.

The Santiago Campaign of 1898

This campaign was initiated by the naval activities which finally shut up Admiral Cervera's fleet in the harbor of Santiago de Cuba. After blockading this harbor for some time, Admiral Sampson finally notified his department that his squadron would not be able to force the enemy from the harbor until the forts at the entrance of the harbor should be captured and thus permit him to remove the mines. A military expedition was organized and transferred to the scene where, after severe fighting for about a week, the hostile vessels ran out and were destroyed or captured by our fleet. In this campaign the disagreements between the naval and military commanders were numerous and injurious to good relations between the two forces, and might have seriously affected the attainment of the end in view. The trouble arose mainly from mutual misconceptions of each other's rôles on the part of the commanders.

The Attack upon and Capture of Port Arthur by the Japanese in 1904

This famous siege is so recent that but little need be said concerning it. The harbor at Port Arthur formed a refuge for the Russian fleet. After several bombardments of the defenses and harbor, the Japanese realized that they would not be able to drive out the Russian vessels and that in continued attempts to do so they would be likely to lose several of their own ships. This they could not afford to risk, so they proceeded to land large armies to invest the place and accomplish their purpose by means of land attack.

The following comments on the subject of combined operations throw light upon the conditions and circumstances existing in the past.

In the expedition of Penn and Venables we have a case of two commanders between whom a bitter feud had existed for years. The same was known to the highest authority, yet these two men were placed in command of co-ordinate parts of the expedition and were practically independent of each other. To insure success the situation demanded the closest co-operation, and a commission was sent with them to effect this result. The commission accomplished nothing and the whole affair terminated in a fiasco. Could any other result be expected under such circumstances?

It will be observed that Wolfe and Boscawen, St. Vincent and Moncton, succeeded in causing the two services to drop their prejudices and jealousies and act in harmony. That this was accomplished is no small credit to those fighters of the 18th century whose prejudices were acute. The feeling of dislike between the services still continued, however, not only amongst the officers but amongst the enlisted men. Professor Laughton writing of the 18th century says: It was strong no doubt on the part of the soldiers but even stronger amongst the sailors, who saw courtly rivals seasick and helpless on board ship but had no opportunity of seeing them in their own field of distinction. The pipe clay and powdered head, the stiff clothing and the etiquette of soldiers, were all repulsive to the tar of olden time.

In this connection, it may be observed, that in the past soldiers and sailors have often misunderstood each other's rôle and have therefore judged each other on false premises.

Seasick and helpless soldiers aboard vessels were not objects to inspire sailors with respect for their usefulness and efficiency, and produced in the sailors wrong estimates of the gallant men, these same soldiers, when in face of the enemy on solid ground.

Even Napoleon never understood naval conditions and the difficulties which confront naval commanders. He was not able to see why a fleet without trained personnel, but of the same size as an opposing one, could not contend successfully therewith. Had he listened to the representations of his naval experts he would have avoided many grave errors prejudicial to his fortunes and would have escaped many bitter disappointments. Marlborough, on the other hand, while projecting and considering great combined naval and land operations, took especial care not to interfere with technical matters of the fleet, but left all purely naval matters to the judgment and decision of the naval committee.

It appears that Wellington, great soldier as he was, never appreciated the difficulty of naval problems arising from a strong and active hostile sea force. This situation was probably one that the navy, with its great and unending obligations at the same time, could not alleviate; and probably a better appreciation on Wellington's part of the rôle and limitations of the fleet would have softened his complaints and turned aside the evil effects of the controversy.

In fact, through this long war, we find that indefensible rivalry and jealousy which characterized the expedition to Cartagena and which ended in such disastrous results.

After the return of the Walcheren expedition each service indulged in such charges and recriminations that the controversy amounted almost to scandal. It is now accepted as a fact, that the land forces on this occasion operated with such lack of vigor and definite plan that no favorable results could have been expected, and the fleet was half-hearted in attempts at co-operation; incompetence was largely responsible. No decisive success can be expected from forces acting without plans and giving to each other only half-hearted or indifferent support.

Let us do away with such incompetence—substituting therefor a definite mission in which both commanders will be indoctrinated and alive to the object to be attained and fully appreciative of the requirements of the situation.

We find but few expeditions of combined forces where harmony controlled the operations: many where disaffection and distrust, jealousy and ignorance, held dominant sway. Where good relations existed the efforts put forth were successful; but where disagreement and strife existed failure marked the end. Have we not here a valuable object lesson and should we not learn clearly what to avoid?

NAVAL ATTACKS UPON FORTIFIED HARBORS

The question of attacks upon our fortified harbors is one that strikes close to home, and one of extreme interest to the personnel of the Coast Artillery Corps. As our coast defenses now stand, the resistance to attack is mainly limited to fortified sea fronts. Our personnel have thoroughly studied this phase of defense, are familiar with the problems that may arise, and have prepared themselves for emergencies. It is therefore with no little interest and confidence that our coast artillery personnel contemplates an attack upon our seacoast works.

Taking our own defenses as a concrete example and considering the caliber and power of our guns and mortars, our efficient mine system of obstructing our harbors, and the training of our personnel in charge of these elements, it is a fair deduction that serious attacks will not be made upon the coast defenses without great injury resulting to the attacking fleet. The odds against the success of the fleet, in such cases, will be great. Efficacious fortifications, manned by alert and well-trained men, will operate passively to accomplish their purpose. And they are likely to be left to exist in peace by a hostile fleet while the latter seeks to fulfil its mission by some other means than by direct attack. These views are based upon the following considerations:

1. Fleets are, as a rule, constructed for the specific purpose of fighting similar ships—to secure, or maintain, sea-power. To secure or maintain sea-power requires a powerful fleet which is costly, and not generally to be risked except for the purpose in hand.

2. Warships are useless against mortar fire; they can not reply to it effectively; and, if subjected thereto, are exposed to great danger without compensating return for the risks taken. Should shore guns withhold their fire until the ships reach mid-range, the latter will be checked in front of mine fields and then exposed to both gun and mortar fire. In the recent experience at Gallipoli, where terrific bombardments took place, several ships were lost and others were seriously damaged without, so far as can be ascertained, appreciable effect on the land works. The abandonment of the enterprise alone shows that it was a failure.

3. The struggle for sea-power is now severe and likely to become more so as the years pass; consequently competition amongst fleets will greatly increase. In such circumstances the loss or injury of a single ship—in an attack upon coast fortifications—not only might be rashness itself, but also might give superiority to the opponent. In this connection let us note the practical equality of our own and the Spanish Fleet in 1898, and again the same with repect to the Japanese and Russian fleets around Port Arthur in 1904. Our own fleet was chary of any exposure that might cause the loss of ships during its blockade of the harbor of Santiago de Cuba, and the Japanese Fleet at Port Arthur at no time seriously engaged the batteries. The Japanese, after several times bombarding the bay, which contained the Russian ships, gave up the attempt as hopeless and called in the army to complete the work. They stuck rigidly to the mission of destroying the opposing fleet with their own, as long as there was a possibility of doing so; but they declined to engage the shore batteries in a contest where they had nothing to gain and everything to lose. A wise policy was followed in the duties required of their fleet throughout the war. Their vessels were too expensive, required too much time for construction, and were too essential in their proper rôle to be sacrificed in useless attacks upon shore batteries.

4. It is not wise for a fleet to engage fortifications while a hostile fleet exists. To engage them and exhaust supplies of ammunition, wear out the crews, and have a number of ships damaged or destroyed, only to be interrupted at the critical moment by the opposing fleet, is not the best preparation for a sea battle. Such danger is not to be risked lightly or without some great advantage that would justify such procedure. In this connection let us recommend the study of the attack of three days upon San Giorgio by the Italian Fleet, before the battle of Lissa.

By all means let us entice the hostile fleet to attack our coast batteries—without fear of the result.

5. History abounds in examples providing evidence that the customary and rational way to capture a fortified port or harbor is to disembark forces on an unprotected shore and attack the place from the rear. Santiago de Cuba, Wei-Hai-Wei, Port Arthur, and many other places confirm this view.

In connection with this plan, an enemy, having decided that an important port or fortified harbor must be taken, will blockade it, land ample forces at a suitable place a few miles away, march upon the rear, and assail it from that direction.

Due to the fact that efficacious coast defenses present an effective obstacle to an enemy's gaining direct possession of a harbor, the defenses will, by their existence, cause the transfer of the attack from the fortified position to another point where resistance will be small or non-existent, and where the blow can be delivered promptly and effectively. The danger passes from the front, where resistance is strong, to a point on the flank or in the rear where it will be weak.

Co-operation in General

MILITARY POLICY

In regard to questions of military and naval development and administration, those pertaining to policy stand first. It has been said with considerable justification that we have no military policy and that officers of both services have nothing to do with matters pertaining thereto. This view is not strictly correct. Officers of the army and navy may not always influence such matters directly, but they do so indirectly; and it may be assumed that many of our most definite lines of military action have come from advice and opinions of military and naval men who have made, in the dim past, official recommendations concerning the subjects involved. Influences which affected the final decisions may have been sown where they were to work out results, long before these great results may have arrived, and after their antecedents were forgotten. Wise and far-sighted principles of policy promulgated early, anticipating the date of maturity, will bear fruit.

The first and fundamental step in co-ordination and cooperation between the army and navy will be the adoption of definite principles of policy affecting the two services, directing the same in their efforts to reach the end in view. Agreement in this respect will reconcile fundamental aims at once and facilitate harmonious arrangements of other details. Therefore let us all strive for a policy embodying the elements of teamwork and point out the course that each is to follow toward the common goal.

CONSIDERATION OF LAW

In continuation of co-operation, after policy has been adjusted, come matters of law. The will of both parties concerned may be anxious for closer and more efficient combined action, and yet be handicapped by legal barriers. It is desirable that the laws governing the two bodies be carefully reviewed and revised, if necessary, to facilitate co-operation. Concrete cases, showing the urgency of closer and more harmonious action, have arisen in the past; and we may be certain that, under the most perfect provisions to remove such embarrassing situations, difficulties will come up again. In order to accept such conditions philosophically each man concerned must feel that all that is possible, within human foresight, has been done to remove the causes of serious differences, and that others that arise must be patiently borne, always keeping the mind on the end in view.

Having made up our minds as to the exact organization best suited to our problem, and having settled upon the general methods to be followed, our laws should be revised and brought into agreement with the leading ideas embraced therein.

Precedence of Rank and Command

A preliminary survey of the general question of combined operations and the problems of coast defense shows that the requirements of an efficient system of co-operation will in many cases require conceptions of command different from those now authorized and accepted. To adjust these will require careful elaboration of the legal structure upon which we are to build, so that in matters of legal significance there will be no room for doubt or quibbling. Considerations embodied in this division of the subject must be wisely and rationally dealt with in order that we may not introduce new difficulties in trying to obviate old ones.

Coast Artillery Corps

The proper status of the Coast Artillery Corps in its relation to the army and navy has often been agitated. Generally speaking, one class has contended for transfer of the corps to naval administration, and the other for retaining the corps with the army. The question is, and remains, a debatable one. It is probably well that no change has been made so far, since our ideas upon many military questions are now maturing and passing through a critical period; and until the hazy conditions of mind now existing have cleared up it is better that important changes have not been made. Time will solve many of our important problems and enable us, by careful treatment, to avoid defects and misconceptions. Within recent years proper views as to the true rôle of the Fleet have been maturing in the public mind, and the change may affect and facilitate the adjustment of such issues as the one now considered, in harmony with proper military policy.

In a country with seacoast, the development of the defenses thereof marks the beginning of an ambition to embark on a quest of sea-power. This motive may not yet have been formulated and may appear only as a purpose to defend against invasion; but the idea grows and finally becomes a well-defined national aspiration. The first idea includes warships, etc., combined with the coast fortifications into a system of coast defense. In time the importance of sea-power, commercially and politically, becomes more and more apparent and finally results in the desire to control the sea. Such control can only be accomplished through an offensive rôle for the Fleet. This point having been realized and established, the Fleet must loosen all bonds that have previously tied it to the coast, and should be left free to go out to sea and fight its battles and win its victories. The soundest doctrine now demands that the Fleet shall go wherever the situation re- res, independently of other considerations, and governed y by the dictates of strategy and tactics.

Long ago Great Britain formulated what is now recognized as the correct principle of sea-power in the offensive doctrine of her fleet, and its release from duties connected with the shore. A third of a century ago Germany transferred her coast defenses to her navy department. The numerous reasons given for the transfer deal directly with the peculiar aquatic conditions connected with coast defenses, the greater adaptability of seamen for such duty, better co-ordination with the naval defense, and relief of the engineer troops of the mine system because they were overworked at times of mobilization. The question here reduces to a matter of defense of coasts by the navy and the coast defense troops. In its broad results the effect of this transfer upon the fleet is not taken into account. In fact, at that time, the German Navy was small, and, with the coast fortifications, it was made a unit for coast defense. The offensive value and use of the fleet had not yet been developed.

The defense of Germany's coast is a small problem, being mainly one of protecting her great naval depots and stations. Taking the view that a navy exists mainly for the passive defense of a short coast-line, in this case no valid argument can be produced against naval control of the coast fortifications, since with Germany's great army nothing was to be feared from invasion from over sea. Co-operation was sought in the change, and without doubt the desired result was secured. However, should Germany secure numerous colonies scattered over the earth, with thousands of miles of sea-coast; should she become a powerful candidate for sea-control; and should her sea-interests rise so as to preponderate over the defense of her land frontiers, as in our own case; then she might find it advisable to reconsider her present organization, sever the existing close relation between her fleet and the coast fortifications, and adopt other relations which might appear better suited to the new situation.

A majority of nations have their coast defenses administered by their navies, and this is often brought forward as an argument in favor of such policy. One might as well reason that the majority of nations have small merchant marines and the United States ought to follow the lead of the majority. As will be elucidated below, it may be added that the navies of the majority of countries, in the modern sense, have been failures.

Through her victories on the sea in the 16th, 17th, and

18th centuries, Great Britain gained control thereof—not by combining her navy with her coast defenses, but by giving the former an offensive policy and relieving the fleet of all anxiety as to the safety of the realm. Her arsenals and fortified places depended as a rule upon the army, leaving the navy free to accomplish its great rôle upon the high sea. Her fleets have cleared the seas of every fleet that has ever sought a decision there with her, and she still holds with a strong hand the power and control she then gained. This result may be taken as an object lesson that should not be passed over without due consideration.

On several occasions France has controlled larger fleets than Great Britain could assemble; and those of the latter have fought the former with the odds in numbers against them. The struggles were always the British offensive against the French defensive, and the latter lost. Today the best French writers are trying to throw off the incubus of a defensive naval policy, but it is so ingrained into their personnel and people that but little progress is being made. The same writers decry the practice of assigning divisions of the fleet to local sections of the coast-line, under command of the district commanders. Notwithstanding the efforts of the more progressive French writers, it is doubtful if their fleet could be maintained at any appreciable distance from their coast for any length of time and win success upon the high sea.

Let it be observed that no nation that has joined its coast defenses and navy under one administration has ever won decisive results upon the sea; while, on the contrary, Great Britain has dominated the sea for two hundred years and still holds it with a grip of steel. The United States, which has always kept her coast defenses and her navy separate, and has followed the offensive doctrine, has had many victories. The same may be said of Japan.

Each nation has its own problems to solve. Our conditions and problems approach more closely to those of Great Britain than to those of any other country; in fact we have the same problem transferred about three thousand miles to the westward. We have our Caribbean, Pacific, and Panama problems, and those emanating from the Monroe Doctrine. These will not be satisfied by any strictly passive defense such as that resulting from naval protection of the shore-line.

In the development of our present navy and the existing sentiment for a still greater one, to maintain a policy already in operation, the great question has passed through many critical stages and the fleet has run serious risks of being diverted from an offensive career and assigned to a defensive rôle on our coasts. This danger has not disappeared by any means. The Jeffersonian gunboat policy, the monitor craze, the mania for grotesque panaceas for eliminating warships and other costly structures, still have their supporters; and there is always a possibility of appropriations for such additions to our armament, in spite of the efforts and recommendations of naval experts.

The possibility of public opinion forcing upon the country an abortive military and naval program is the gravest danger to which we may be exposed, and no step should be favored that in any way will give encouragement or aid to the irresponsible idiosyncrasies of the public.

The coast-defense batteries and personnel are placed between the mobile land and the naval forces. The navy is to operate offensively on the sea; the coast batteries play only a passive defense seaward; and the mobile land forces play the defensive while the enemy disembarks, and their action should then become offensive. The Coast Artillery Corps and the mobile forces are under obligation to prevent hostile landings at undefended places and to repel an enemy that may have landed; hence the nature of their action is clear and definite. All of these forces must work in close harmony in order to perform the duties prescribed for each; and the three rôles must be combined into one principle, one representing the expectation of the armed forces. Co-operation of one set must not be sacrificed to the advantage of another, except for the strongest reasons.

We may now consider the arguments for and against the proposal to transfer the coast artillery service and armament to the control of the Navy Department. Omitting minor reasons which in time would adjust themselves to the new conditions, which ever way the question may be decided, the following propositions appear to embody the fundamental military arguments for and against this transfer:

1. Better co-operation and understanding between the coast artillery service and the navy would be secured.
2. Co-operation between the coast artillery and the mobile forces acting along the coast would be weakened or perhaps destroyed.

3. It would tend to—and in fact would—weaken the offensive sentiment in the navy, and would endanger the offensive rôle of the fleet upon the sea.

These are all important subjects which can not be ignored and must receive the full consideration which their importance demands.

Unquestionably there will be a gain in co-operation, by a closer bond between the coast artillery and the navy, in so far as these two bodies are concerned; but it remains to be considered whether the gain will be great enough to justify other losses that will inevitably result. In this connection we must also consider the degree of co-operation that can be secured without the transfer. The net gain will be represented by better harmony and agreement between the bodies united, diminished by what can be secured without the union and by the imperative sacrifices made in other directions.

In reviewing the history of combined naval and military operations it was found that coast defense questions play an insignificant part therein. The only cases where these will enter the discussion at all will be where naval forces are assigned to coast defense commands for local defense, or where the naval forces are driven in and are blockaded. Under proper regulations no serious question should arise in such cases, and it appears that the gain from the change would be small. The writer has not been able to find any reference to disagreements under such circumstances; the important disagreements of which history furnishes unlimited examples belong to military operations decidedly different from those now under discussion. From the improbability of attacks being made upon coast batteries—as already discussed—and from the absence of historical instances of serious disagreement under the circumstances affecting our coast artillery problems, it appears that the alleged urgency for the proposed transfer and the advantages resulting therefrom have been greatly exaggerated.

It may be conceded without argument that, in preliminary arrangements and in preparation in time of peace, co-operation between the two services will be imperative. Co-operatve systems of information and communication, familiarity with each other's rôles, matters of education and doctrine (not ignoring the study of organization and administration), can be effected in time of peace without transfer. Great strides have already been made in co-ordination in connection with the coast guard service, regulations for convoys, submittal of questions to a joint board, etc., and through a general awakening of interest in the subject. After all that laws and regulations can accomplish, it remains for mutual interest, reciprocal understanding, and sympathy to be the governing factors of successful co-operation.

In the campaigns of Santiago and defense of Port Arthur serious difficulties arose between the military and naval commanders; and in the latter case were aggravated by the military commander's arbitrary attitude. The coast artillery personnel, however, was not embroiled in the controversy.

In regard to lack of harmony, misconceptions generally exist as to causes and facts. This question of co-operation is much larger than it is generally assumed to be; and coast artillery matters affect, only in a small way, the main broad question.

The gain in teamwork to the coast artillery and navy, by union, would be more than offset by the loss of the same between the former and the mobile forces provided to cover the intervals of coast between fortifications. The shore-line marks the limit of the naval offense: the same line marks the beginning of the land defense. This line appears to be the natural line or division between the sea and land forces. In case the proposed transfer should be effected, there would be either no co-operation between the coast defense personnel and the mobile forces, or it would have to be attempted between two different services without a common head; and the authority of naval and military departments would mingle and overlap, thereby interjecting disagreements and confusion *ad libitum.*

There are two points of view from which the function of the coast forts may be contemplated. One in which they are viewed as a number of small isolated places of local significance only, with their whole attention turned seaward, and disconnected from the forces that may lie on the flanks or to the rear. This, in the writer's opinion, is a narrow and erroneous conception of the mission of fortified places and is wholly inapplicable and impracticable for a period of war. It ignores the strategical value of the fortified place the principal danger to which the same are, and will remain, exposed.

The other view is that the naval and military forces, including the coast forts and their armament, should, and in fact must, form one great defensive scheme in which each will play its proper part in proportion to the obligations placed thereon; according to strategical principles, each supporting the others and co-ordinating its operations to the full extent of its powers. In this view a coast fort must connect with, and take into account, all forces that may act in its neighborhood, no matter in what direction or capacity; it must cooperate even to the extent of turning its guns to the flanks or rear to support them should the same be hard pressed or in danger. Movable armaments may be compelled to assist the field forces engaging the enemy. A little imagination only is required to see the possibilities and obligations which may arise.

The question of defense for our coasts is now entering upon a new era. Guns in fixed emplacements no longer answer the requirements of the case. Under the new conditions we must look to guns mounted upon railway trucks, and to be fired therefrom. Perhaps the heaviest calibers will be transported to previously prepared emplacements along the shore, thus directly defending great lengths of the shore-line with heavy guns.

The service of the movable guns for land and seacoast fortifications is now placed by law in the hands of the Coast Artillery Corps. The same system of movable guns may be required in severe battles miles from the fortifications, in cooperation with the mobile forces striving to maintain the integrity of the coast defense *nuclei* and supporting points of the general defense. The effective action of such armaments may decide the fate of an important place.

In discussing this phase of coast defense one must look to the future and to new methods which will be commensurate with the task imposed. One must cut loose from the old, narrow, and limited conceptions of the subject which will be found inapplicable and wholly inadequate. It appears to the writer that in this direction will lie the real field of co-operation for the coast artillery defenders; and this subject will be one which cannot be disposed of by a paper transfer and without a moments thought, as if no such problem existed. It may easily become the main problem of defense, growing out of an invasion and efforts of the land forces to drive back an enemy, and it will rank with the offensive problem of the fleet. The solution will not be secured by ignoring it. It will be in this field of operations that misconnections will be most likely to happen and that great misfortunes may result.

The injurious effects which may result from attaching an offensive fleet to a branch of the service which is passively defensive cannot be measured beforehand, but the fundamental antagonism in the two methods concerned would lead one to look for difficulties. The coast battery is not likely to be affected by transfer to the navy, but the fleet will be seriously affected. We have many examples of fleets being assigned to a defensive-defense of the coasts, of their becoming glued to the same, and of their suffering actual deterioration to such an extent that they could not remain in the open sea or fight there. Due to this effect upon the French Fleets during the wars of the French Revolution and Empire several of their squadrons remained most of the time shut up in harbors. The Russian Fleet, at Port Arthur, remained within the harbor and looked to the fortifications to protect it. The same happened to the Chinese Fleet at Wei-Hai-Wei. These three nations are conspicuous amongst those which have placed their coast defenses under their respective navy departments. In all three cases their system resulted in the coast defenses protecting the fleet, instead of the latter protecting the coast.

In a country like ours, where public opinion, though generally wrong, plays such an important part in military affairs, it will be a dangerous experiment to connect the Navy Department with the fortification forces provided to defend the coast. Such policy will greatly facilitate the retention of the fleet, on public demand, to assist the fortifications, thereby nullifying the offensive doctrine and mission which should always govern the fleet. A coast defense commander, possibly exaggerating his danger, or under-estimating his powers of defense, and supported by strong backing from his community, might not meet with insuperable difficulties in convincing the single head of the composite department that the urgency and importance of the situation justified withholding the fleet from its proper offensive rôle, in order to support him against an attack. Only one man and one department would then have to be convinced, instead of the two under existing organization and administration. The sentiment of the fleet might also lean towards this decision, as at Port Arthur, making the defensive policy for the fleet easy. An offensive naval service might, and probably would, soon degenerate into a defensive rôle pure and simple.

Regulations

When once the proper laws have been provided and have become effective, a general survey of the field should be made covering legal and other necessary matters, and the same should be incorporated into a set of regulations to guide officers in the performance of duties touching both services. Requisitions and methods of supply should, as far as practicable, be interchangeable. Sanitary and personal records should be identical so that each party will become familiar with the forms used. Details will naturally suggest themselves, and will be easily worked out as the subject develops.

Conventions

Out of the adjustment of co-operation between the two services as now organized a system of conventions will grow up and soon facilitate the smooth running of the same. These would not necessarily be matters for regulations, but would stand as a guide for all concerned in reference to subjects embraced under certain heads.

Reciprocal Education

The education of officers of each branch in the problems, duties, limitations, rôle, and possibilities of the other, will bring out clearly the motives, methods, loyalty, etc., of the other, and will accomplish more in the desired direction than all other efforts combined. The greater the number of officers that can be thoroughly instructed by this method, the less friction will be developed on contact with one another, and the nearer we shall come to perfect agreement and harmony.

Doctrine

In serving together, or even studying together, the same general considerations as to doctrine will come up. Each service should prepare a well-developed doctrine whose details would be known to the other. In combined military and naval operations this will be imperative, since each service generally must know the outline of the other's plans, and the objective, before intelligent action can be taken. Each should furnish information, the force, route, mission, and rôle, and cover all other points that are likely to come up during an expedition. It should then take but a few minutes for each side to run over the other's outline and detect and eliminate any inconsistencies and other possible causes of trouble.

Acquaintance and Good Will

The more the officers of both services serve and study together, the better they will become acquainted, the greater will be the sympathy between them, and the better will they learn to work together in harmony and with eye-single to the end in view. This subject is on a par with that of education mentioned above, and, like it, is a cogent factor in conciliation and mutual understanding.

CONCLUSIONS

The foregoing illustrations, although limited in number, show that disasters have often overtaken great and well planned expeditions for want of harmony between the military and naval services concerned, principally through the quarrels of their commanding officers. The expedition of Penn and Venables to the West Indies in 1655 is typical and teaches a valuable lesson. An armed guard sent for the purpose of counteracting the bad blood between these men might have preserved peace; but it could not have created harmony, and disaster would have followed in due course of time. The moral that may be drawn from this expedition is, that it is unwise to send out commanders under such conditions who have had personal differences. Do not select men to command, in ventures of dual command, who have what is usually denominated "tempers." Fire them out of the service; do anything you wish with them; but do not give them command and authority where such peculiarities are certain to come out, to wreck good relations, and to sow disorganization and disaster in their wake.

These illustrations also show that other expeditions of similar make-up have ended in success and have effected far-reaching results through the rare good judgment of the separate commanders, who acted together in hearty co-operation and as one body in their operations. The capture of Quebec in the Canadian campaign indicates how well Wolfe and Boscawen worked together. Coming down to more modern times, the Japanese Army and Navy always acted in hearty co-operation. Whenever it appeared advisable that the fleet should be present with the army, there you found it taking its share of the burdens and fighting as if the whole burden rested upon its own shoulders. On the other hand the Russian Fleet at Port Arthur never, as a fleet, co-operated with the army, and rarely attempted to assist the latter in operations where, on numerous occasions, naval assistance could have been given and would have been invaluable. Stoessel appears to have sought to stir up feeling between the two forces and to have succeeded in the most emphatic manner. This is proof in itself that he was unfit to command in such a situation. In these accounts we have proof of the danger of misunderstandings and misconceptions in such warfare and the direful effect they may have on the result. They also show that combined operations of the army and navy can be carried out peacefully and satisfactorily, depending on the men charged with the responsibilities thereof.

Our Cuban campaign furnishes an example of the danger of misunderstandings, between the two commanders, which might have had a serious ending, and which probably would have been obviated had each of the commanders had a proper appreciation of the other's rôle and limitations. This case emphasizes the necessity for education of officers of each service in the rôle and general requirements of the other.

We need a policy which will develop mutual understanding, sympathy, loyalty, and good will between the services, supported by suitable laws, regulations, and doctrine.

Policy governing both services, and building up proper procedure in the relations of the services to each other, is the most important thing required to bring out and maintain complete harmony between them.

In reference to the transfer of the coast defense service to the Navy Department, arguments unfavorable to such course preponderate over those favorable thereto. It has not yet been shown that the desired end cannot be accomplished without such transfer. The question cannot be determined by the merits which appear therein in their limited effect upon the coast defense service alone, but by the effect upon all the elements of defense affected thereby. All the elements with which the transfer would interfere must be considered, and the question must be decided by the evidence bearing upon the whole.

The offensive spirit of the Navy must be developed and maintained. No act should ever be permitted to cast its shadow across the path of this important doctrine.

Co-operation within the general scheme of the defense on land must be maintained and fostered. The forfeiture of essential co-operation in this field will not be compensated for by a small gain somewhere else. The hearty co-operation of the coast defense and mobile forces defending the coast-line is imperative and will more than counterbalance the gain in efficiency which will be added to the coast defense service through the proposed transfer.

The integrity of the naval offensive, and the highest efficiency of the coast defense service in full co-operation with the mobile forces on the coast, are the two great military considerations that the country has before it.

The remedies proposed herein will not remove all friction that may develop in the premises, but they will eliminate most, if not all, of the causes therefor; and they will reduce to a minimum the differences which may arise. When we have succeeded in this, but little more can be expected. Thereafter each man with clear and intelligent grasp of the main purpose or objective must act "*according to his conscience, the best of his understanding, and the custom of war in like cases.*"

THE RESERVE OFFICERS' TRAINING CORPS IN THE LAND GRANT COLLEGES

By Captain ROBERT R. WELSHIMER, C. A. C., U. S. Army

Origin

The Reserve Officers' Training Corps in our educational institutions originated with the National Defense Act of June 3, 1916. As far as Land Grant Colleges are concerned, this training corps may very properly be considered a logical development of the Morrill Act of 1862, together with the various acts—Adams—Nelson—Hatch, etc.—which are supplementary thereto.

History

A clear understanding of the possible beneficial results to the individual student, the educational institution, and the nation, made possible by the late National Defense Act, necessitates an understanding of the object and results of the Morrill Act, and the acts amendatory to it.

The Morrill Act brought our Land Grant Colleges, represented in general by our state universities and agricultural colleges, into existence. These institutions represent an enormous area in the field of higher education. They offer diversified courses, they are accessible to all classes, and they are patronized by thirty-five thousand students representing every section of the nation. These institutions may be regarded as the most logically available centers for training citizen soldiers at a minimum of expense, and a minimum of interference with preparation for careers in civil life—provided their available equipment is utilized to the best advantage.

The Morrill Act provided specifically that institutions chartered under its provisions include Military Tactics in their curriculum. The act was passed in 1862, when the great Civil War was in progress. The provision for Military Tactics was evidently inspired by the serious shortage of trained soldiers at the beginning of that war, especially those fit to become officers, and the consequent terrible suffering and loss of life due to the incompetence and inexperience of commanders. The main object of the military training provided for was to qualify the average student as an officer of volunteers. The Morrill Act authorized certain annual federal appropriations for land grant colleges which included Military Tactics in their courses. In 1915 the National Government paid out $2,500,000 for this purpose; and since 1862 the total expenditures amount to over $125,000,000.

The results obtained up to the present time, either from a purely educational or a military point of view, can hardly be considered commensurate with the enormous expenditures. In many cases institutions were very indifferent in their compliance with the spirit of the act, and received little or no financial aid or other assistance from the state in which located. Their object was to obtain a maximum federal appropriation, for which they rendered a minimum military return to the nation. They used the federal appropriation for any part of their educational system other than military. On the one hand, such institutions evidently believed that military training was of no value to them or the individual; while on the other hand, the indifferent training received was a positive detriment to the nation.

Indifferent military training is undoubtedly demoralizing to the educational institution and the individual, for the very excellent reason that indifference to exactness, concentration, physical development, respect for authority, and those very things which are the real essentials of military training—in other words, *discipline*—react through such indifference to accentuate and develop the faults of the individual, instead of correcting them.

Indifferent military training is a detriment to the nation because it gives individuals absolutely the wrong idea of what really constitutes adequate military training. Such individuals generally find the military course a drudgery, an irksome duty which they perform in the easiest way—getting it over with as soon as possible. They find nothing interesting in it; see no value in it; realize they have learned very little; then, on leaving the institution, they disseminate improper military ideas, discourage "George" from taking this course, and criticise the army of which they really know nothing.

The results obtained at these indifferent institutions were so inferior that many military authorities strongly advocated abolishment of military training as provided for in the Morrill Act. Fortunately, however, there were certain institutions which had taken hold of the mechanism of the Morrill Act and provided a standard of military training as high as could be expected within the limitations of that act. These institutions used federal appropriations for the upbuilding of the military department, and in some cases obtained large appropriations and other aid from the states for this purpose. It was due to the influence and the results obtained by this class of institutions that the system has not only been retained, but has been given enlarged opportunities for military instruction by the Act of June 3, establishing the Reserve Officers' Training Corps. The indifferent class of institutions—referred to above—find no further place in this paper. It is desired rather to follow the course of those institutions which utilized the opportunities of the Morrill Act to the best advantage. I believe that in this latter class of institutions, while they never lost sight of the fact that the military training was primarily for the development of volunteer officers, it was realized that military training was a real value to the institution itself, and formed a very important element in the education of a college student. This attitude is not inconsistent with rendering an adequate military return to the national government, for adequate military results are obtained at the same time as the purely educational benefits.

VALUE OF MILITARY INSTRUCTION TO THE INDIVIDUAL AND THE INSTITUTION

DISCIPLINARY VALUE

It is a lamentable fact that our country is full of young men whose mothers are too weak and whose fathers are either too busy or too indifferent to control them. The number of this class of parents is apparently increasing. Their offspring have a very slight conception of authority and also very little respect for it. Such youths need a proper discipline—a discipline, "fundamental, vigorous, and absolutely impartial." They need to be taught the meaning of power and authority. Experience shows that discipline, respect for power and authority, and obedience do not originate even chiefly from any intellectual conviction. Intellectual conviction should, however, be used to the utmost extent in securing discipline and obedience; but even so, there always must be present the real source of power—that is, "the shadow of the big stick in the background." No military training can ever teach a boy the discipline he should have learned at home. For the undisciplined boy, discipline is of very great value when taught by men who make a study of each individual's character; who teach discipline understandingly; who use reason and common sense freely—the "big stick" rarely.

PHYSICAL TRAINING

All of us, old and young, are inclined to neglect even the simplest laws of health which dictate that we carry ourselves properly, breathe properly, and—above all—take exercise. College athletics do not reach the masses; certainly neither the lazy man nor the bookworm. Yet these are the very ones who most need systematic exercise. Military drill forces students to exercise regularly in fresh open air; teaches them to stand, walk, and breathe properly; and its greatest merit is that it catches every student.

CHARACTER

"No one can properly control others who cannot first control himself." In military training the student is taught, first, how to take orders and how to obey them. Next, he is given minor responsibility in commanding others: in proper military training he is coached on his faults. As fast as his ability to use power advances, he is given increased chances to command. He is taught to understand the value of character reading. The student who becomes a cadet officer has an excellent opportunity to study his men, learn their individual traits, learn how to get the best results from them, and then build the individuals into a real organization. Surely the boy who learns the power of control, and has a real knowledge of men, has learned a lesson which should materially benefit him in any business or profession. The student acquires: a realization of the obligation of citizenship; a high standard of personal honor and truthfulness; and the lesson that he should both enforce respect for his own rights and recognize the rights of others.

INTELLECTUAL BENEFIT

Many boys are indifferent students simply because they do not know how to study, how to apply themselves, and how to concentrate their minds. Military drill teaches the power of concentration, for it demands the absolute attention of each individual as long as it lasts. This is true for the man in ranks as well as for the non-commissioned officers and officers.

As a man progresses, however, more demands are made of him. When he becomes a corporal, sergeant, or officer, and has the actual handling of troops, he is also called upon to use his originality and constructive ability to a marked extent. He must act quickly, logically, and always within the dictates of common sense. For the development of constructive ability, facility in arriving at a definite common-sense plan of action, following that plan to a logical conclusion, and especially for the development of the power of concentration—for these, military training is the equal of any college course.

If the military instruction be carried further than merely drilling under arms—so as to include instruction in ballistics and gunnery, ordnance matériel, military engineering, and tactics—it offers an excellent application of the student's theoretical knowledge obtained in his regular academic course. There is no better review of mathematics than is found in its application to the theory of ballistics and gunnery; excellent applications of mechanics, principles of mechanism, and drawing are found in the study of ordnance matériel; the problems of the military engineer demand a practical application of every study the engineering student takes in college; and in tactics the student solves original problems which require that knowledge of fundamentals, drawn from the storehouse of his memory, be applied and expressed logically and concisely in order to develop the best common-sense solution. Surely these results are a valuable educational asset.

DEMOCRACY

The following is quoted from the address of Dr. Edmund J. James, president of the University of Illinois, before the Military Committee, House of Representatives, on the subject of "Our Land Grant Colleges as Centers of Military Training":

> This military drill is one of the most democratizing elements at work in our student body. It crosses all lines of college, church, fraternity, or social organization. It is susceptible to no pull or favoritism. It measures all classes, rich and poor, idle and industrious, social and misanthropic, by the same standard and insists on efficiency or elimination. Its principle is "do" or "get out"—a most desirable antidote for the enervating policy of indulgence pursued by so many American parents and college faculties which tends to develop a race of mollycoddles and inefficients.
>
> I am not disturbed by the fears of some of my pacifist friends that such

military drill as we are proposing will develop a militaristic spirit. This nation is much more likely to go to pieces upon the greed of Mammon, or indulgence in the lust of eye and of the flesh, or the pursuit of pleasure and other dangerous rocks of that kind than upon any development of a warlike spirit.

The democratizing element is a most important one. President James has stated that, from the point of view of the educator—even under the Morrill Act—this alone was sufficient to justify military drill in colleges. If this were true under that defective system, certainly its benefits can be greatly increased under an improved system. A working plan for so doing is suggested later in this paper.

RESULTS UNDER THE MORRILL ACT

The above educational results may be obtained in almost any degree of proficiency. If the military training is indifferent, the educational results will be indifferent and inadequate to meet the needs of national defense. Experience showed that under the Morrill Act effective results were not generally attained. Let us see why! In doing this I take the University of Illinois as an example. I am more familiar with conditions at Illinois, and moreover I believe it to be typical of those few institutions—out of a total of fifty similar ones—which complied with the spirit of the Morrill Act. The State of Illinois, the President of the University, and the faculty supported and encouraged the military within the limitations of the law.

Under War Department General Orders No. 70, 1913, the University of Illinois is designated as Class C: that is, a college or university not essentially military, where the curriculum is sufficiently advanced to justify a degree, and where the average age of the students on graduation is not less than twenty-one years. The total federal appropriation for this institution in the fiscal year 1916 was $122,422.14. During the two years ending March 31, 1915, the total expenditures on account of the military department were approximately $235,000.00, of which $227,918.00 was expended on what is probably the largest armory or drill hall in the world, and the balance for incidental expenses, including military scholarships to cadet officers. It will require $250,000.00 more to complete the armory. An excellent, well drained, drill ground of twenty-five acres has been provided. A stock-judging pavilion was erected which will also be used as a riding hall; and a building was provided for use as headquarters of the field artillery battery. All this in addition to the general equipment which one finds at a first-class university.

The enlargement of the expenditures is due to state assistance. The State of Illinois has seriously contemplated its duty to the nation in this particular. President James, of the University of Illinois, has realized the necessity and advantage of military training and has pushed it; the press—especially *The Chicago Tribune*—has exerted its wide influence for military service. As a result, the people of the state favor military training, they take just pride in what is accomplished, and the state legislature has responded to the demands of the situation most liberally.

Since 1901 the military organization has expanded from a regiment of infantry, an ineffective battery of foot artillery, and a band to what might be called a Reinforced Brigade consisting of:

1. Two complete regiments of infantry—including bands, headquarters, supply, and machine gun companies.
2. A reserve band.
3. A trumpet and drum corps.
4. A battery of field artillery. (Battery F, 1st Regt. F. A., I. N. G.)
5. An engineer company.
6. A signal company.
7. A hospital company.

All of the above units were developed under the provisions of the Morrill Act. There are 6150 students in the University of Illinois, 2289 of whom take military training.

In carrying out the spirit of the Morrill Act and G. O. No. 70, War Department, 1913, the University used the following system:

1. All students were required to obtain five credits in military training, out of a total of 130, to entitle them to graduate. Any student excused from "military" for any purpose whatsoever had to make up these five credits in some other department.

2. During the freshman and sophomore years practical military drill for two periods a week (from 4:10 to 5:10 P. M. each period) was compulsory; except that members of the band were allowed to substitute their work for military drill, and fixed numbers of athletic men out for 'Varsity teams were

excused for a part of the year without loss of credit for military drill. This practical drill constituted four of the above mentioned five credits.

3. Corporals and sergeants were selected from the sophomore class; lieutenants from those of the junior class who elected to continue the military course and whose qualifications were considered the best. Juniors and seniors were given no credit for graduation although they attended the same number of practical drills that earned four credits for freshmen and sophomores. Juniors and seniors did, however, receive a military scholarship valued at $24.00 per year; were presented by the University with a sabre and belt upon graduation; and were commissioned by the Governor of Illinois as brevet captains, Illinois National Guard.

4. The practical drill was supposed to cover the following:

Infantry.—Infantry drill regulations, small-arms firing regulations, bayonet exercises, ceremonies.

Artillery.—School of the cannoneer and battery, dismounted.

Signal Company.—Signalling by semaphore and wig-wag flag codes, telegraph, wireless, and heliograph.

Engineer Company.—Field engineering, map reading, entrenchment, bridge building.

Hospital Company.—U. S. Army Hospital Corps drill regulations.

Note.—Gallery practice was required of all cadets.

5. All freshman cadets were required to take theoretical instruction in infantry drill regulations for one hour per week during the second semester. This earned one of the total of five credits given for "military." Certain selected senior cadet officers were utilized as instructors in this subject at a salary of $100.00 for the term.

6. Theoretical instruction in infantry drill regulations and small-arms firing, under supervision of the Commandant, was required of all sophomore sergeants for one hour per week throughout the year. No credit was given for this work, but a sophomore could not be a sergeant unless he took it; and if a sophomore were made a sergeant, whether he desired the position or not, the course was compulsory. This same course was *recommended* but not required of corporals, and open to others.

7. Junior and senior commissioned officers were required to take one hour per week theoretical instruction throughout the year in field service regulations and tactics under the

supervision of the Commandant, but no credit towards graduation was given.

8. Cadets were uniformed at their own expense in an olive drab uniform, similar in all respects to the U. S. Army service uniform.

9. Cadets were considered to be under military discipline only during the hours of practical military drill. No regulations were published requiring wearing the military uniform properly at other than drill periods, or for requiring military courtesies when in uniform and not at practical drill.

Working along the above lines the University has for three consecutive years been rated as distinguished in its class. In institutions of this class the results obtained were well worth while accomplishing, both from an educational and a military point of view; and the authorities and cadet officers deserve the greatest credit for what has been accomplished. The results do not, however, meet the demands of our national defense. It must be remembered that the above rating was merely comparative: an unbiased examination of the actual results attained, even under the most excellent system evolved under the Morrill Act, as outlined above, were not as great as might appear from a casual reading of the requirements—this for the reason that the practical instruction was not mastered and the theoretical instruction was indifferent. The Morrill Act possessed certain defects which were insurmountable by any university; and even the excellent system, which institutions of the distinguished class used in complying with the spirit of the defective law, was not perfect.

Defects Under the Morrill Act

It is impossible to discuss the defects of the system developed by an institution under the Morrill Act apart from the defects of the act itself: for while in some respects the defects were entirely due to the attitude of the institution, in other particulars the law was either entirely at fault or partly so. Defects pertaining to each will therefore be discussed together.

GRADUATION CREDITS

A university regulation which gave five credits for military work was very good as far as it went, but it did not go far enough for the best results. These five credits were obtained for doing two hours per week of practical military drill during the freshman and sophomore years, and for one hour theoretical work during the second semester of the freshman year. An examination of the system previously outlined will show that the student who completed four years in the military course—the student who was in earnest—did during his entire course an amount of work equivalent, in the case of other studies and laboratory work, to 15 hours. Nevertheless, the 15 hours work accomplished by this earnest student—10 hours more than done by others—gained him only five credits for graduation, which was the same amount gained by the indifferent student—the one who took the military course because he had to, and who exerted a correspondingly poor effort toward proficiency.

It may be argued that, in lieu of credits for this work, sufficient other inducements—in the form of higher office, which carried with it a certain amount of honor; the probability of a military scholarship; and the possibility of a small compensation as a student instructor—were sufficient without the actual graduation credits.

The above, however, is true only to a limited extent. For while the spirit among most cadet organizations is excellent and very commendable, observation shows that there is room for very much improvement before military proficiency will be classed by students as a really great honor. Nevertheless, this commendable spirit is growing and has been especially noticeable during the last few years. Again, the financial consideration was so small that it appealed only to the student who was making his own way. These students deserve the highest respect and the greatest consideration; the present efficiency and spirit in the best cadet organizations are due very much to their efforts; and it is a pleasure to express appreciation of their work: yet it is well within the realm of possibility that, had sufficient inducement in the way of credits been offered that class of students to whom the small money remuneration did not appeal, they also would have continued military work and would have made as good, or better, officers.

The academic departments were not permitted to encroach upon the military course for the time assigned for the practical drill of freshmen and sophomores and for the theoretical instruction of freshmen. Study cards took these hours into consideration—for they were credit hours, and were therefore considered as the equal of any others in determining the maximum number of hours per week that a student could carry.

However, in the case of junior and senior officers and sophomore sergeants—to whom no credit was given—the academic department did encroach upon the military department, and students were required to crowd their military work into study cards when they already had as many hours as they could properly carry. The logical result was that many students registered themselves in these military classes only to neglect them. What was the difference when there was no credit? This condition was especially noticeable in the case of sophomore sergeants. They were *required* to take Theoretical Military, with no credit; whereas the juniors and seniors could have avoided it by not electing to continue military during those years. All sophomores were required to attend two hours practical drill for which they were given two of the five credits; but if any particular sophomore was selected as a sergeant, he had to devote an extra hour to theoretical instruction—for which he was given no credit. Human nature is the same with students as with others—it is too much to expect something for nothing. As a result many sophomores, who might have developed into most proficient military men, looked upon being made a sergeant as a penalty. They preferred to do practical military drill as corporals or privates and thus obtain their two credits, rather than to do this same practical drill as a sergeant with an added hour of the theoretical, but with no more credit hours than were obtained by the corporal or private. The system put a premium on inefficiency and lack of ambition.

The defects due to lack of credits were primarily the fault of the institution. However, the attitude of the academic departments was undoubtedly influenced by the fact that student instructors were used, and they realized that such a system was ineffective. The use of students for instructors was necessitated by the defect in the law which did not permit the detail of sufficient army officers for instructors. As will be seen later, the necessity for student instructors has been eliminated by the late National Defense Act.

If military training is of educational value, due credit for the work should be given. If credit cannot be given for every hour, the system of credits should at least be developed along lines which will offer the greatest inducements for all classes of students to continue the military throughout their entire course.

DRILL PERIOD

The drill periods of two hours per week give a very short time in which to accomplish much. During the months of November to March, inclusive, weather conditions generally necessitate indoor drill. The number of cadets was so great that the indoor feature, even with the spacious drill hall, practically limited the work to the monotonous repetition of the manual of arms and close order movements. These are necessary, but their advantage is their disciplinary value. Any drill, which is continued too long, and is not of a varied nature, loses even a disciplinary value. These conditions give little opportunity for field work—yet this is what is most needed, and what would secure and retain the interest of students more than anything else. Again, the system does not make the work sufficiently progressive: that is, a sophomore, or a junior, or a senior, does the same monotonous drill which he did as a freshman. This condition should be avoided. The time is short, but if utilized to the best advantage—under a systematic, progressive system—somewhat more can be accomplished, especially in the direction of field work. Certainly the monotony can be avoided.

The hours for drill—4:10 to 5:10, P. M.—were bad. This hour should, so far as possible, be a recreation hour. After a hard day's work the students will not give the attention which military drill requires. The boys are tired—want to get home; so they do their drill with too much "Do and get it over with" spirit. This will not develop concentration and it has little intellectual value.

University athletes were excused from the military part of the year because drill interfered with athletics. Such time as they did devote to "military" was done in a perfunctory way only to secure possible credits—for an athlete realized that the system barred him from such advancement as the military course offered to others. This had a bad effect on the *esprit de corps.* A college athlete always has been—and always will be—looked up to by his fellow students as more or less of a hero. They are, generally speaking, the most popular and best known men in the student body. They may not all be leaders, but as a class they have the qualities which make for leadership. They are a type much needed in student military work, and their addition to the Corps of Cadets on a footing of equal opportunity with all others would go a long way toward improving the student's feeling toward military work. Any military schedule which seriously interferes with athletics will be impracticable; but it should be possible to set aside a drill period which would make athletes available for it, without seriously affecting athletics.

Giving student bands credit for military work was very proper. However, the appearance and effectiveness of the bands could be materially increased, and without undue interference with their musical training, if they were given some practical instruction in the School of the Soldier—that is, saluting, marching, facing, etc., and also in First Aid.

SELECTION OF OFFICERS

The principle of the merit system, combined with the elective system, was the only workable one at institutions of this class. The defect laid in not giving credits to sophomores who were made sergeants—thus offering an incentive for proficiency and continuance, instead of putting a premium on inefficiency. If the sergeants obtained were not always of the best material, then the officers (who were selected from the sergeants) were not always the best that could have been obtained. If the training be developed along progressive lines, the noncommissioned officers and officers should be selected on merit, and in a way to cause them to progress along with the units themselves. As soon as a freshman enters the university, a Military Individual Record Card should be prepared as outlined later in this paper and a careful record maintained during the course. Under the system outlined above, the Commandant, who was the only regular army officer present, could not know each individual of the large number of cadets. Therefore, in making appointments for responsible positions, he had to be guided almost entirely by the recommendations of cadet officers. In many cases these cadet officers recommended only those who asked them to do so; with others a degree of favoritism crept in; while still others were, while meaning well, simply incompetent judges of men. Military efficiency in these organizations should be "susceptible to no pull or favoritism"; its principle should be "do" or "get out."

PRACTICAL DRILL

The schedule of practical drills was quite comprehensive. However, due to the small number of hours devoted to this drill—and especially due to the fact that for 50 per cent of the time the weather conditions necessitated indoor drill—the comprehensive schedule outlined on page 361 was not adequately covered. Lack of sufficient competent instructors was also a contributory cause. Field training was what was needed, but the system practically prohibited it. Even now the comparatively small numbers of hours will hardly be increased materially, and at most places an indoor period is unavoidable. The most that can be hoped for is to utilize the small time available to the best advantage. That is, generally speaking, to do in the indoor period only those things which do not have to be done in the open—such as bayonet exercises, gallery practice, physical drill, first aid, etc., making the drill period during this time shorter, and adding the time so dropped to the drill period during the outdoor season. This will permit of accomplishing a maximum amount of field work. Short drills, varied frequently during the indoor season, will make the military course more attractive by avoiding the objectionable, long, monotonous drills—while the long drill periods during the outdoor season will offer opportunity for interesting field work. In addition the system should be such as to offer inducements for attending training camps of the Federal Government where additional field training will be obtained.

There have been no target ranges available at most institutions for range practice. Likewise, camp sites have not been available, although it would have been an excellent idea to have placed the cadets in camp for a few days. However, the Federal Government did not provide the range or camp sites. It is to be hoped that the states may do so.

The Federal Government has furnished only obsolete equipment consisting merely of arms, bayonets, and belts. This has placed a serious handicap on the institutions in trying to do proper practical work. Had they been furnished with equipment similar to that of the regular army—including camp equipage and field equipment—they could have accomplished much more.

THEORETICAL INSTRUCTION

The theoretical instruction of freshmen has been given in classrooms, one graduation credit being allowed for the same. This instruction has been along proper lines. However, student instructors have been used and they have hardly been competent to secure the best results. The instruction has been for one semester only. It should have been carried on throughout the year, and better results under a competent instructor could have been obtained if the instruction had been along practical lines in the armory, instead of in a classroom. It is necessary to give the freshman absolutely correct instruction in the fundamentals. If this is not done, incorrect methods learned by him are carried on throughout his course and eventually he teaches these same incorrect fundamentals to others.

Theoretical instruction given to sophomore sergeants has supposedly been given by the commandant; actually, however, for lack of time, the commandant has utilized student instructors for this work. This system has been open therefore to the same defect as was pointed out above. All sophomores should have been required to take the one hour theoretical instruction throughout the year. No credits have been given to sophomore sergeants for this work. This has been defective—radically so—as discussed under "Credits."

Theoretical instruction of juniors has been in exactly the same status as that of the sergeants, except that they were supposed to have progressed to the study of field service regulations and tactics. Previous instruction having been so inferior, however, they have not been properly prepared to take up these subjects. It is a waste of time to try to teach advanced subjects when the fundamentals have not been learned. Similar remarks apply to the instruction of seniors—except that, as the commandant has conducted these classes personally, it has been possible for him to correct errors in fundamentals and impart at the same time some information in the advanced subjects.

As a whole, the theoretical instruction has accomplished little in a military way, and from an educational point of view has been of no practical value. The instruction system for freshmen possessed the merit of giving credits; that for seniors, of having a competent instructor. A combination of these two systems, continued throughout the course, would solve the problem.

REGULATIONS FOR THE MILITARY DEPARTMENT

Such regulations as have been published were a part of the regulations for undergraduates—they were inadequate. Comprehensive regulations for the Military Department should be published separately and issued to each student. Cadets could be seen wearing their uniforms in all sorts of improper—even fantastical—ways and all ideas of military courtesies were missing. No penalties were provided for the man who did his practical drill indifferently. If he did not *cut* drills he would get through. A demerit system would improve this condition.

Regulations should include: a clear, concise statement of military courtesies; a requirement that all students in uniform will observe them; a provision for the infliction of a penalty for a failure to observe them; and a requirement for enforcement by the academic faculty, the military instructors, and cadet officers and noncommissioned officers. Similarly, regulations should require that when the uniform is worn it must be worn properly. Also, the regulations should include a full statement of the entire military course, together with credits given.

RECENT LEGISLATION

The institutions really interested in military work realized the existence of the defects mentioned. They tried for several years to secure their elimination so far as the law and War Department regulations were concerned. The War Department was not convinced of the merits of the system under the Morrill Act; believed the results attained inadequate; and doubted if it were possible to secure adequate results even if more comprehensive laws were passed. Finally, however, the educational institutions interested the War Department and Congress in their behalf; and then requested the following provisions of law for military training at Land Grant schools:

> First, that the land grant colleges, as a peculiar group, be distinctly recognized in the law and administration as sources from which a considerable number of officers and men may be drawn for the various branches of the military service.

This was accomplished by the National Defense Act of June 3, 1916.

> Second, that service with cadet regiments of the land grant colleges shall be counted for officers in the regular army as service with troops.

The above request was not included in the law. It is very unfortunate that it was not. On the subject of details of regular army officers for college duty, Major-General Leonard Wood has said:

> The main difficulty we have nowadays is to secure suitable officers for this college work, for officers, like other men, are not all fitted to teach;

they are not all possessed of those peculiar qualities which attract young men and make a task sometimes uninteresting, interesting. In other words, there are many admirable officers who are not adapted to take hold of the work at institutions such as you gentlemen represent.

When General Wood made these remarks only 100 officers were required—now, 300 are required. If the difficulty he mentioned applied then, it applies more so now. It is a fact that college details are not popular details in the minds of officers. When we apply this attitude to the case of the limited numbers of the class referred to by General Wood, the matter becomes serious.

The attitude of officers is due primarily to three causes: First, most officers realize that the best position professionally is service with troops. Second, if they go on detached service, they hope to secure a detail which offers the best professional advantage, combined with congenial surroundings. Third, they realize that all detached service carries with it a very considerable element of increased expense, which has to be met from the returns of a very meager salary. In other words, they regard a college detail—especially at a land grant college where quarters are not furnished unless some personal element is predominant—as carrying with it small chance for professional advancement, and all the penalties and expense of detached service. At military colleges quarters are furnished, which helps to counteract the increased expense—especially as the manner of living, requirements of clothes, etc., is about the same as at an army post. This gives the military college an advantage over the Land Grant school, when it comes to a choice of a detail. Congress cannot be expected to meet the expense disadvantage. That applies to most detached service. Congress would hardly discriminate in favor of one class. Yet the penalty for detached service might very properly have been removed.

Third, that at least one officer shall be detailed to every land grant college maintaining a satisfactory cadet force, and in the case of regiments numbering at least eight hundred, one officer of not lower rank than Major shall be detailed, and in the case of a corps of 2000 and over one officer of not lower rank than Lieutenant-Colonel or Colonel be detailed.

A specific provision to this effect was not passed, but there is nothing to prevent the detail of an officer of the rank indicated.

Fourth, that additional officers of suitable rank be detailed, one for each group of five hundred cadets or fraction thereof.

This was granted by the present law.

Fifth, that such noncommissioned officers of experience and training shall also be detailed as the circumstances and needs of the force demand.

This law made adequate provisions for these details. It is the intention of the War Department to detail one enlisted man for each one hundred cadets. What has been said above, in reference to details of suitable officers at educational institutions, will apply even to a greater extent in the case of enlisted men.

The War Department hopes to detail enlisted men of the following qualifications:

a. They must be temperate, intelligent, and well instructed in their military duties.

b. Must have at least common school education.

c. Must be qualified temperamentally and in soldierly bearing to associate with students and to properly represent the interests of the United States in their associations with the faculty and the student body.

d. Must be in such physical condition as would permit the proper performance of their duties.

Men with all the above qualifications are not many. Generally speaking, the type desired will probably be represented by the noncommissioned officer of long service and experience, who is married, has a family, and is settled in his habits. Now the War Department proposes to give men so detailed, commutation of quarters and heat and light for one room. This will amount to about $18 per month. Commutation of rations will be given at the rate of $1.00 per day. They will also have their active pay which is very small. The man of the type mentioned is going to have a very hard time to make ends meet on account of the financial considerations, and it is doubtful for this reason alone whether sufficient men will apply for the detail. In order to obtain properly qualified men, a university will be very wise which offers these enlisted men some financial inducement, or which at least furnishes them quarters in the same way that they will receive quarters at the military college.

Sixth, that the Secretary of War be authorized to furnish such arms and supplies to these institutions as they may ask for, and as in his opinion will be wisely used.

This was most generously granted by the law. Institutions may now obtain the same supplies, arms, equipment, camp equipment, etc., as are furnished for the regular army.

> Seventh, establishment of a four-year course in military training, open to such students as may desire to take it. This course may be combined with any other course and be completed in six, five, or with the approval of the Secretary of War even less time. A graduate of this course to be admitted to the regular army as a Second Lieutenant, with Lieutenant's pay, and upon completion of this service to be assigned to the Reserve Corps. Students who enlist for this course to be paid $250 per year for each of the years of the course approved by the Secretary of War.

This was provided for in a modified form.

Of the seven requests for legislation which the land grant colleges asked, four were granted practically as requested, two were granted in modified form, and only one refused. Having secured substantially what was requested by the institutions, it would appear that they have now secured the mechanism which they thought necessary for an efficient system. The laws recently passed and G. O. 49, War Department, 1916, prescribing the manner of execution of the law, constitute what will be known at the land grant colleges as *Reserve Officers' Training Corps*, Senior Division—composed of units of cavalry, artillery, infantry, etc.

RESERVE OFFICERS' TRAINING CORPS

By the Act of June 3, 1916, the Reserve Officers' Training Corps consists of units; that is, cadet organizations of the medical corps, signal corps, cavalry, field artillery, coast artillery, infantry, etc., established by the President in those universities, colleges, and schools which apply for the admission of such units to membership in the corps, and agree to the regulations prescribed by the Secretary of War for the government and training of said units. All units so established are Federal units. They are organized primarily for the adequate training and enrollment in a Reserve Officers' Corps of 50,000 men, competent to be captains or lieutenants of volunteer organizations in time of war; and, secondarily, to impart sufficient knowledge of military science to fit every person enrolling in the corps as a soldier adequately trained to fulfil the obligations of citizenship—that is, defend the "Stars and Stripes."

There are two divisions of the Reserve Officers' Training Corps—a Senior Division and a Junior Division. The Senior Division may be organized at institutions requiring four years of collegiate study for a degree (including land grant institutions) and at essentially military schools, not conferring academic degrees, but which are especially designated by the Secretary of War. The Junior Division may be organized at any other public or private educational institution. In this paper we are concerned only with the Senior Division, that being the class established at Land Grant institutions.

It should be noted that at Land Grant institutions established under the Morrill Act, and pursuant to that act, all students are required to take military training. If, however, such Land Grant institutions organize under the law establishing the Reserve Officers' Training Corps, all students enrolling in that corps thereby comply both with the provisions of the Morrill Act and the Act of June 3, 1916. Should they not so enroll in the Reserve Officers' Training Corps, they are still available for military training under the Morrill Act. Eligibility to membership in the Reserve Officers' Training Corps is limited to students who are citizens of the United States, not less than 14 years of age, who are physically fit to perform military duty or will probably be so upon arrival at military age—excepting members of the Army, Navy, and Marine Corps of the United States, or of the National Guard, or Naval Militia. The President is authorized to detail not to exceed three hundred active officers as professors and assistant professors of military science and tactics at institutions maintaining units of the Reserve Officers' Training Corps. Practically, this will make one such officer available for each group of 500 cadets. Similarly the President may detail such numbers of enlisted men as he deems necessary for duty with the units of the training corps.

The Secretary of War prescribes standard courses of theoretical and practical instruction for the different classes of units, and institutions are required to adopt the prescribed courses into their curriculum. Freshmen and sophomores are required to devote at least three hours per week per academic year to the prescribed military training. They may attend training camps at the expense of the Federal Government. Students completing two years service, whose military efficiency is such as to justify the president of the institution and the professor of military science in selecting them for further training; who volunteer therefor by agreeing in writing to continue in the Reserve Officers' Training Corps for the remainder of their course at the institution, devoting at least five hours per week to the military training prescribed; who also agree in writing to attend two courses in camp training at federal expense, for a period not to exceed six weeks per year: these students will be paid the value of the garrison ration (approximately $108 per year), when rations are not furnished in kind, during the remainder of the student service in the Reserve Officers' Training Corps. A student completing the four-year course may, upon application and under such regulations as the President of the United States prescribes, be appointed an officer in the Officers' Reserve Corps, provided the applicant agrees to serve in such capacity for ten years, and provided further that the total number so appointed does not exceed 50,000. Any graduate of the Reserve Officers' Training Corps may, on application, be appointed and commissioned by the President as a Temporary Second Lieutenant in the Regular Army in time of peace for further instruction, for a period not exceeding six months, with pay at $100 per month. On completion of such service the temporary second lieutenant reverts to the status of a Reserve Officer. The Federal Government will uniform the various units and will equip them so far as possible with the latest model of arms, personal equipment of the soldier, camp equipment (including tentage), etc., as is furnished similar units of the regular army. Either the institution or the individual student must secure and pay for prescribed text-books.

Once the course for the Reserve Officers' Training Corps has been entered upon, it becomes a prerequisite for graduation. War Department orders contemplate—but do not specifically require—that graduation credits be given for all hours spent in military work; and these orders also prescribe a definite, progressive, four-year course in both practical and theoretical military—for three hours per week during the first two years, and five hours per week during the last two years. Small-arms range practice is contemplated, but no federal appropriation was made for providing a target range. Orders permit the university authorities to excuse certain specified classes of students—such as law students, athletes, and members of the band—from enrolling in the Reserve Officers' Training Corps. However, students so excused receive none of the benefits of the Act. Original War Department orders also contemplated that the military instruction be completed before 4:30 P. M., so as not to interfere with the natural recreation period; but a recent War Department order specifically states that university authorities will retain their original powers of supervision and control—that is, those which they exercised under the Morrill Act. Under this provision, therefore, institutions may still designate recitation and drill hours with no more regard for the military result than in the past. It is intended that noncommissioned officers and officers—as far as practicable—be appointed from the junior and senior classes.

Under War Department orders, juniors and seniors who have enrolled in the training corps are required to attend a four-week training camp at the *end* of the junior year and another four-week camp on the *completion* of the senior year. The time selected for these training camps is unfortunate. The requirement that seniors attend a camp subsequent to graduation places an unnecessary hardship on the student. At that time the student will have completed his academic course and will be ready to enter on his life work. To delay making his start until after completion of a training camp may deprive him of opportunities for positions, and as a result he may have to begin his profession in civil life with more or less of a handicap. Again, the cadet organization is deprived of any benefits which might result from the services of that student, because he will never return to serve as a cadet after having gained experience in the senior training camp. Students will be quick to note these defects, and they may deter many students from continuing the junior and senior military work. It is true that they may avoid these defects by attending a training camp during their first two years, since the War Department will consider attendance at any two training camps as complying with the law. Nevertheless, it appears that a better solution would be to require juniors and seniors to attend the training camps at the *beginning* of the junior and senior years—or, more properly speaking, at the *end* of the sophomore and junior years. This would give the institution the benefit of the experience gained by the student and at the same time would—without interference with the military requirement—permit the student to complete the four-year military course in coincidence with his academic course, thus freeing him immediately on graduation for his work in civil life. *This defect could easily be removed by a War Department order, and is of sufficient importance to an institution to justify it in requesting the Department to do so.*

As before stated, the Reserve Officers' Training Corps embodies practically every improvement which the institutions requested of Congress. However, if we now compare the military courses as contemplated by these new laws and orders with the courses previously explained as typical under the Morrill Act, it will be seen that what is required now is not very different from what was attempted before by the most proficient institutions. If an institution should elect to comply only with the letter of the new law, the system it requires would not in itself give results sufficiently better than before to be commensurate with the greatly increased expenditures necessitated on the part of the Federal Government. A careful analysis of the new law shows only the following improvements which an institution cannot avoid: more officers and enlisted men of the regular army detailed, thus providing better supervision of work and eliminating any necessity for student instructors; theoretical instruction of all sophomores; furnishing uniforms and best equipment available; small money remuneration to juniors and seniors, together with requirements that they attend training camps if they volunteer for military work during those two years. If an institution lives up merely to the letter of the law, the following defects are present: the two-hour practical drill period per week is too short to permit of field work, and necessitates monotonous, close order, indoor drill for winter months; the drill period may be at recreation hour; athletes may still be non-available; giving credits for work done may be avoided; sufficient inducements to cause juniors and seniors to volunteer for service may not be offered; military discipline, customs, and courtesies—except while students are actually at drill—may not be enforced; there may be no range for range practice—nor camp for camp training, except as provided for juniors and seniors; there is a possibility that academic departments will encroach upon the military department and make it impossible to secure students in theoretical classes of proper and uniform size; also that academic departments may not consider military work of value and may prevent students from registering and taking it when they already have more hours than they can properly carry. Any institution that desires to obtain the best educational results possible from military training—in discipline, physical development, character training, intellectual benefits, and the spirit of democracy—must not be content to comply only with the letter of the law but must go further and comply also with the basic spirit of the law, thereby eliminating the defects which still exist and taking the fullest advantage of the improved mechanism offered by the new law. The institution must do real constructive work. This can be done without undue interference with academic work; and, if done, it will not only result in better educational benefits, but will also comply with the requirements of our national defense.

Model System for Proper Development of Reserve Officers' Training Corps

In developing a system of military training which will comply with the real spirit of the law and be constructive, the personal point of view of the student—that is, the human element—must be given due consideration. The majority of students—like all other boys of the same age—are more or less irresponsible. Without an element of compulsion, few would take military training; since, however, for two years at least, they are compelled to take it, the system during that time should be planned so as to avoid the most disagreeable features from the student's view-point. These are: drill during recreation hour, lack of variety, and lack of credits for work done. At the same time the system should be of maximum effectiveness and offer the greatest incentive for a student to continue military training during his last two years, when the continuance is entirely within the student's discretion.

1. The institution should make every effort to secure, by means of a state appropriation, a camp site and a target range, as near the university as possible.

2. Similarly, the institution should provide a shooting gallery, so designed as to permit the use of a large number of rifles at one time.

3. The Regular Army Officers detailed as Assistant Professors of Military Science and Tactics, and such enlisted men as are available as assistants to the regular army officers should be assigned to fixed units of the cadet organization. The same instructor and assistants should have the personnel of their units under themselves alone for both theoretical and practical instruction. This is highly important, for to obtain the best results the instructor must have the same individuals under himself alone at all times: First, so that he may have better opportunity to learn their personalties and qualifications; second, so that he may properly co-ordinate his methods of theoretical instruction with the practical side.

To permit this system, it is absolutely necessary that the university authorities assign fixed hours for theoretical instruction of all classes and that the academic departments must not be permitted to encroach upon the hours so assigned. To secure proper assignment of the individuals under the right instructor, and to regulate the size of sections, it is necessary that *the military department* be authorized to assign individuals to particular sections, consistent with the hours set aside for a particular class: this assignment to be made and posted for the information of students before registration in other studies. The student may then adjust his academic studies so as not to interfere with the military requirement. In this connection it should be noted that it is sometimes the attitude of both students and academic departments to crowd military instruction in "any old place," regardless of the number of hours carried or the size of the sections which result. Theoretical military work should be counted as of equal value with any other study in determining the maximum number of hours a student can carry. Satisfactory hours should be available without undue interference with academic work. The theoretical instruction of freshmen, on account of the uniform feature suggested below, should properly follow the practical drill period.

At first glance the system proposed above may appear very arbitrary, but if one will stop to think that only four instructors are available to impart one hour's theoretical instruction per week to approximately 2000 freshmen and sophomores, and three hours per week to approximately 110 juniors and seniors (that is, one regular army officer for each group of 500 cadets constituting one of the four different classes), the system should appeal not only as being not arbitrary, but as offering the only practical solution consistent with efficient results.

4. Open the university for the registering of freshmen four weeks prior to the general opening. Organize these students into company, battalion, and regimental units; appoint the officers and noncommissioned officers from available juniors, requiring such appointees to report at the same time as the freshmen, and pay them a reasonable sum for the four weeks' work. Put these units in camp under intensive military training. Until such time as a camp site is available, have them live as students ordinarily do, but the entire four weeks to be devoted to military training under a prescribed schedule.

Under the old system—and even under the new—the greatest defect lies in not being able to give the freshman a proper start. The time allotted is too short to teach him proper discipline, and also too short to impart the absolute perfection required in the fundamentals. As pointed out previously, the freshman acquires indifferent instruction and improper ideas of military training which he carries through his entire course, and finally teaches to others. It is essential, if the best results are to be obtained, that this defect be eliminated. It can be done by carrying out the above suggestion. Give the military authorities a chance at those boys for four weeks. It will improve them physically, and they can be taught things of real military value so that the outdoor period of the school year can be devoted to field work, and the indoor period to short disciplinary drills and physical exercises to keep the units up to standard. The freshmen will become acquainted, thus developing the spirit of democracy to a marked extent; they will enter the university with more class spirit; and they will be be better adjusted to conditions, and better equipped mentally and physically to settle down to academic work promptly on the general opening of the university.

Most institutions examine all freshmen physically. This could be done during the camp period. The military authorities could work in conjunction with the Dean of Men and could thereby assist him in becoming acquainted with the personnel of the new class. Every student should be taught to swim, taught a proper carriage, taught how to take exercises to eliminate his physical defects—all these results can be attained during the camp period. In addition, if an institution took advantage of the period suggested and obtained the services of an expert in physical development, like Captain Koehler of the U. S. Military Academy, even better physical results could be obtained.

If this matter were taken up with the War Department, and its attention invited to the fact that a university proposed to establish an annual training camp for four weeks' instruction of several hundred freshmen, it is very possible that the Department could be prevailed upon to designate such camp as a training camp within the meaning of the recent National Defense Act. If this were done it would mean that the students could attend the camp and obtain transportation thereto at government expense. This would eliminate one of the possible objections to this plan; that is, the fact that some students would not be able for financial reasons to enter a university one month early.

5. The members of the student bands should not be enrolled in the Reserve Officers Corps. Since, however, they would thereby be deprived of the benefits under that Corps—that is, uniforms furnished by the Government and small pay when juniors and seniors—their uniforms should be furnished by the university, and juniors and seniors should be given military scholarships. They should be allowed the same graduation credits for practical drill as freshmen and sophomores under the old system; that is, four. In consideration of these inducements they should be given instruction in the school of the soldier, marchings, band maneuvers, and instruction in first-aid, under direction of the military department.

The band is a university institution which is of great value both to a university and to the students themselves. It is now a military asset, but under the above scheme will become more so. The bands should be encouraged to the limit. The value to the institution is great enough to justify giving the bandsmen out of the university funds what they lose from the Federal Government because the members would be barred from the Reserve Corps. Athletes do not pay for athletic uniforms: for just as good, or even better, reasons the band should not have to pay for band uniforms.

6. Give any freshman or sophomore who attends a summer training camp one credit toward graduation for each training camp, but do not excuse them in any way from "military" in the university.

Under the law juniors and seniors must attend training camps. But while freshmen and sophomores may do so at federal expense, they are not required to do so, and no inducement for so doing is offered. The credits are offered as an inducement. Those who attend such camps should not be excused from any part of the university training. They will have been compensated by the credits, and generally speaking the men who attend training camps will be of more value to the organization than the others.

7. Establish a custom of appointing officers and non-commissioned officers of the junior class, in so far as possible, from those students who have attended training camps.

This is a means of obtaining more efficient officers and noncommissioned officers, and also is an additional inducement for students to attend training camps.

8. Publish a pamphlet of *Regulations of the Military Department*, and issue one to each cadet. These regulations to contain:

a. "Uniform requirement." Uniform required to be worn only for practical drills, and for theoretical instruction of freshmen, and at cadet dances. Mixed uniform, of civilian clothes and uniform, not permitted, except that the civilian overcoat may be worn with the uniform. When worn at all, the uniform must be worn properly, blouse or shirt buttoned at all times, unless otherwise ordered, and the cap to be worn squarely on the head, not shoved back.

Uniform A.—Cap, O. D. shirt, collar of shirt turned down, regulation black four-in-hand tie, breeches, leggins, regulation tan shoes.

Uniform B.—Cap, O. D. shirt, with collar up, blouse, breeches, leggins, regulation tan shoes.

b. "Military courtesies and customs." Publish what these are in short concise form, requiring students to learn them and observe them at all times when in uniform.

c. Establish a demerit system, to cover failure to observe uniform requirements, failure to observe military courtesies, and for improper performance of practical drill—standing in practical drill to be based on record determined by this system, together with data on individual record card mentioned below.

d. Require all members of the administrative faculty, all noncommissioned and commissioned officers, and all army officers and enlisted men to enforce requirements (a) and (b). Require all army officers, enlisted men of the army, officers and noncommissioned officers to enforce requirement (c).

e. Rules and penalties for lates, absences, and for making up drills missed.

9. Maintain an individual record card for each student during his course in military training, showing approximately the following:

	REPORT BY STUDENT OFFICERS	REPORT BY MILITARY INSTRUCTOR
FRESHMAN YEAR		
1. Any previous military training? If so, how long and under whom? ------------------		
2. Is it your present intention to take military for four years? -------------------------		

	REPORT BY STUDENT OFFICERS	REPORT BY MILITARY INSTRUCTOR

3. Do you take military because you are interested or because you have to?
4. Military appearance?
5. Personality?
6. What athletics?
7. Voice for commands
8. Scholarship I, II
9. Standing in practical military I, II
10. Standing in theoretical military I, II
11. Are you going to a training camp?
12. Physical condition
13. Recommendation

Demerits

SOPHOMORE YEAR

1. Is it your present intention to continue military next year?
2. What fraternities or societies?
3. Did you go to a training camp? If so, what record?
4. Class or athletic honors?
5. Improvement in military appearance
6. Improvement in physical condition
7. Improvement in manner of command
8. Scholarship I, II
9. Standing in practical military I, II
10. Standing in theoretical military I, II
11. Recommendation
12. Are you going to a training camp?

Demerits

JUNIOR YEAR

1. What class or athletic honors?
2. What fraternities or societies?
3. What recommendation from training camp?
4. Any improvement in military appearance?
5. Any improvement in physical condition?
6. Any improvement in manner of command?
7. Scholarship I, II
8. Standing in practical military I, II
9. Standing in theoretical military I, II
10. Recommendations

Demerits

SENIOR YEAR

1. What class or athletic honors?
2. What fraternities or societies?
3. What recommendation from training camp?
4. Any improvement in military appearance?

	REPORT BY STUDENT OFFICERS	REPORT BY MILITARY INSTRUCTOR
5. Any improvement in manner of command?		
6. Any improvement in physical condition?		
7. Scholarship I, II		
8. Standing in practical military I, II		
9. Standing in theoretical military I, II		
10. Will you apply for commission in Reserve Officers' Corps?		
11. Will you apply for commission as temporary Second Lieutenant in the Army?		
12. Recommendations		
13. Was he commissioned a Reserve Officer?		
14. Was he commissioned a Temporary Second Lieutenant in the Army?		
Demerits		

ACTION OF COMMANDANT

Freshman Year:

Sophomore Year:

Junior Year:

Senior Year:

The objects of the individual record card are:

a. So that each student will know a careful record of his work is being kept: that efficiency, not favoritism, will count.

b. To encourage and teach student officers to study and estimate the men under them.

c. To inform the president of the institution and the commandant in making appointments in cadet organization, and recommendations to the War Department.

10. All officers and noncommissioned officers of the freshman units to be selected from the junior class. If sufficient juniors are not available, utilize the most proficient freshmen themselves as noncommissioned officers.

Officers and noncommissioned officers of the sophomore units to be selected from the senior class; any deficiencies in the noncommissioned officers to be made up by utilizing most proficient sophomores. The sophomore units to be composed of companies of minimum strength, in order to permit the utilization of a maximum number of seniors as officers and noncommissioned officers and thus give them the greatest opportunity for experience in responsible positions of command.

This system contemplates the organization of freshmen and sophomores separately.

The instruction of sophomores should be—and orders contemplate that it will be—different; that is, more advanced than that of freshmen. This idea should be encouraged. The system above proposed is such that no officers—and probably no noncommissioned officers—will be appointed in freshman units who have not had all the instruction of freshmen, all the instruction of sophomores, and who have not attended at least one training camp. Similarly, all officers—and probably all noncommissioned officers—of the sophomore contingents will have had all the instruction of freshmen and sophomores, will have been officers who have gained experience in the elementary instruction of freshmen, and will have attended at least one training camp.

If there is not a sufficient number of juniors for noncommissioned officers of freshman units, and not enough seniors for noncommissioned officers of sophomore units, it will be better to use freshmen themselves as acting noncommissioned officers in their contingents, and available sophomores as acting noncommissioned officers in their units, for by so doing all finally obtain all the instruction offered by the progressive system. If, on the other hand, due to an insufficient number of juniors and seniors, noncommissioned officers of the freshman contingent were selected from the sophomore unit, they would miss the instruction of the sophomore unit. and will not be so well prepared for officers later. It is not probable that there will be more juniors available than are required for freshman units; but, if there are, they should be made noncommissioned officers in the sophomore unit.

11. It is recommended that Military Scholarships be granted to all juniors and seniors.

No credits are recommended for practical drill to juniors and seniors in connection with the freshman and sophomore units, in view of the fact that the Federal Government pays the student approximately $108 per year. The scholarship feature will, however, be an incentive for juniors and seniors to continue the "military."

12. Divide the practical instruction period into an "Indoor" and an "Outdoor" period. Instruction to be given as outlined below under schedule of courses. Hours to be as follows:

Indoor Period.—(Months of November, December, January, February, and March.)

Drill call, 7:45 A. M.; recall, 8:30 A. M.; on Mondays and Wednesdays for one unit; on Tuesdays and Thursdays for the other unit.

Outdoor Period.—(Months of September, October, April, May, and June.)

Drill call, 9:30 A. M.; recall, 12:00 M. on Saturdays, for both units. On one Saturday in the fall and on three in the spring—to be designated by the Commandant—drill call to be at 8:00 A. M. and recall on completion of the field maneuvers. This field maneuver period will also serve to make up for any Saturday periods called off on account of inclement weather. Any person absent from a Saturday drill period could be required to make up the same from 8:00 to 10:00 A. M., the following Saturday, and he also could be used to especial advantage in outlining the enemy, representing hostile patrols, etc. The same would apply to athletes who, on account of trips, will miss an occasional Saturday period.

It is difficult to find a drill period that meets conditions and which is not open to some objections, either on the part of the institution, the student, or the military authorities. The periods suggested above appear to offer the most advantages, as follows:

a. They do not come at the most logical recreation hour.

b. They give the student exercise early in the morning during the five months in the year that he is most likely to neglect it. It is short; and if the drill be properly conducted it should avoid monotony and should fit the student better to perform the day's academic work. Exercise will help him physically and inspire him mentally.

c. They come at a time when the student should not be mentally tired. Thus his power of attention may be secured, and his power of concentration developed.

d. They shorten the time a student must wear his uniform. During the indoor period most students will have time to change to civilian clothes before the first academic class.

e. They permit the attendance of athletes without interference with athletics.

f. They will be more acceptable to those students working their way through college, for in many cases this class of students drop military work at the end of the sophomore year because the evening drill period interferes with their outside work. The drill period suggested above will not interfere so much, and many such students will be glad to continue "military" for the last two years, in order to secure federal compensation.

g. The Saturday drill period offers opportunity for effective extended order drill and field maneuvers—which are most needed. They should relieve monotony, and it is to be hoped that they will appeal to the student. (If some morning other than Saturday—or even some afternoon, other than Saturday afternoon, which does not interfere with athletics—could be designated, it would be even better.)

13. That the theoretical instruction of freshmen, on subjects outlined below under schedules of courses, be held in the armory. The theoretical requirements of G. O. 49, W. D., 1916, to be combined with practical instruction under the supervision of one regular army officer for each section, assisted by one cadet instructor—who should be given a reasonable compensation—and by enlisted men of the army. The hour to be from 9 to 10 A. M., freshmen to be required to wear uniform for this instruction, and to attend in sections designated by the military department. Instruction to be on Monday, Tuesday, Wednesday, Thursday, and Friday.

The main object of the above system is to teach the freshman how to apply theory—it is the laboratory method. Also it permits competent instructors to handle large numbers of students.

14. Theoretical instruction of sophomores—as per schedule of instruction below—to be held in designated classrooms from 10:00 to 11:00 ,A. M., or some other specific hour, individuals attending in sections designated by the military department. Instruction on Monday, Tuesday, Wednesday, Thursday, and Friday.

15. Theoretical instruction for juniors: Mondays, Wednesdays, and Fridays, 11:00-12:00, A. M., or some other specific hour. Course outlined below.

16. Theoretical instruction for seniors: Mondays, Wednesdays, and Fridays, 1:00-2:00, P. M., or some other specific hour. Course outlined below.

17. Adequate credits should be given for all military work. Suggested credits are tabulated below.

18. SCHEDULE OF COURSES—DEPARTMENT OF MILITARY SCIENCE

All freshmen and sophomores, and all juniors and seniors taking "military," must reserve the eight o'clock hour two days in the week, and Saturday mornings for practical military drill. One unit will drill on Mondays and Wednesdays, and one unit on Tuesdays and Thursdays during the "indoor period"; both units will drill on Saturdays during the "outdoor period." Assignments to units will be made by the Commandant.

Practical drill will be held as follows:

INDOOR PERIOD

(Months of November, December, January, February, and March.)

Mondays, Tuesdays, Wednesdays, and Thursdays: Drill call, 7:45 A. M.; recall, 8:30 A. M.

OUTDOOR PERIOD

(Months of September, October, April, May, and June.)

Saturday: Drill call, 9:30 A. M.; recall, 12:00 M.; except that on one Saturday in the fall and three in the spring, to be designated by the Commandant, drill call will be 8:00 A. M. for Field Maneuvers, recall on completion.

FRESHMAN YEAR

Practical. First and Second Semesters Mil. 1. (a) Credits 2.
2. (a)

Indoor Period

Physical drill; school of soldier, squad, and company; preliminary instruction, position, sighting and aiming drills; gallery practice; nomenclature of rifle and equipment.

(Physical drill will be under the Director of Physical Training.)

Outdoor Period

Infantry drill—close and extended order—and maneuvers.

Theoretical. First and second Semesters Mil. 2 (b)
3 (b) Credits 1.

A note-book of prescribed form will be required.

Hour 9-10, A. M.	M.	T.	W.	T.	F.
Instructors	Sections No.				
(Regular Army Officers)	1	5	9	13	17
	2	6	10	14	18
	3	7	11	15	19
	4	8	12	16	20

Theory of target practice, individual and collective; tables of organization; map reading: service of security; personal hygiene; lectures on military policy of the United States and obligations of citizenship; service of information; combat, including small tactical exercises; drill regulations, to include the school of the company; camp sanitation for small commands.

Text-book: *Manual of Military Training* (Moss).

SOPHOMORE YEAR

Practical. First and Second Semesters. Mil. 3 (a) Credits 2.
4 (a)

Indoor Period

Physical drill; bayonet exercises; guard mounting and guard duty; collective firing on indoor range; ceremonies; signalling; first aid; and sand table work.

Outdoor Period

Extended order drill; close order drill, to include the school of the regiment; ceremonies; intrenchments; range practice; field maneuvers; patrols; advance guards; rear guards; scouting; firing problems; and signalling.

Freshmen and sophomores are not required to attend a U. S. summer training camp. If they do so attend they will still be required to take military training at the university. Freshmen and sophomores are advised to attend these camps. They may do so at federal expense, and for attendance and satisfactory completion of the course of training graduation credits will be given by the university as follows:

Freshmen—Credits, 1.
Sophomores—Credits, 1.

Theoretical. First and Second Semesters. Mil. 3 (b) Credits 2.
4 (b)

Hour 10-11, A. M., (or some other specific hour).

	M.	T.	W.	T.	F.
		Sections No.			
Instructors (Regular Army Officers)	1	5	9	13	17
	2	6	10	14	18
	3	7	11	15	19
	4	8	12	16	20

U. S. Infantry Drill Regulations, to include the school of the battalion, and combat; lectures on military policy; map reading; camp sanitation and camp expedients; recent military history; small tactical problems in patroling, advance guards, rear guards, flank guards, and trench and mine warfare; orders; messages; marches; and camps.

Text-book: *Manual of Military Training*, including maps, (Moss).

JUNIOR YEAR

Practical. First and Second Semesters. Mil. 5 (a) Credits 0.
6 (a)

Indoor and Outdoor Periods

Duties consistent with rank of noncommissioned officers and officers in connection with freshman units. Also see under Mil. 5 (b) and 6 (b).

SENIOR YEAR

First and Second Semester. Mil. 7 (a) Credits 0.
8 (a)

Indoor and Outdoor Periods

Duties consistent with the rank of noncommissioned officers and officers in connection with practical drill of sophomore units. See also under Mil. 7 (b) and 8 (b).

JUNIOR CLASS

Theoretical and Practical. Prerequisite: freshman and sophomore military. First and Second Semesters. Mil. 5 (b) Credits 2.
6 (b)

Three hours per week: Mondays, Wednesdays, and Fridays, 11-12, A. M., or some other specific hour.

Instructors	Section	Room	
(Regular Army Officers)	1	..	Individuals will be assigned to sections by Military Department.
	2	..	
	3	..	
	4	..	

Thirty-six hours of the above time will be devoted to practical instruction—which will include drill, tactical walks and problems; military sketching; minor tactics; map maneuvers, company administration; military history; rules of land warfare; property accountability; and methods of obtaining supplies.

Text-books: *Manual of Military Training* (Moss); *Problems in Troop Leading*, including maps; *Military Topography* (Sherrill); *Rules of Land Warfare.*

A note-book of prescribed form will be required.

SENIOR CLASS

Theoretical and Practical. Prerequisite: Junior Military.
Mil. 7 (b) Credits 2.
8 (b)

Three hours per week: Mondays, Wednesdays, and Fridays, 1-2, P. M., or some other specific hour.

Instructors	Section	Room	
(Regular Army Officers)	1	..	Individuals will be assigned to sections by Military Department.
	2	..	
	3	..	
	4	..	

Thirty-six hours of the above time will be devoted to practical instruction—which will include drill; tactical walks and problems; sand table work; and military topography, including military sketching; tactical problems, all arms combined; map maneuvers; court martial proceedings; international relations of American growth of principles of international law as embodied in American diplomacy, treaties, etc.; general principles of strategy, planned to show relations between statesmen and soldiers; and lectures on military policy and military history.

Text-books:—*Technique of Modern Tactics,* (Bond and McDonough); *Studies in Minor Tactics,* including maps (School of the Line); *Field Service Regulations; Manual of Military Training* (Moss).

A note-book of prescribed form will be required.

19. That the university furnish the Military Department with facilities for making up mimeographs of practical military information, so that the same may be issued to each student for file for future use. Also an adequate clerical force for this purpose. The information so compiled to be co-ordinated by the commandant. Students should be required to provide a proper note-book.

The time for imparting information is limited. Lectures given are soon forgotten. The system suggested will permit of giving students a maximum amount of information which can be retained for reference and should be of considerable practical value at training camps or in the time of war.

20. That the university purchase for the use of juniors and seniors sufficient sets of the following maps so that each such student will have both sets complete:

One set Gettysburg-Antietam 3-inch maps, mounted	$1.00
One set Gett. Bonn. Kings. and Knox 3-inch maps	.15
	$1.15

21. That the university establish an elective course in "Ordnance and Gunnery," to be open only to seniors taking military. Course to be for three hours per week throughout the senior year, carrying six graduation credits. This course to include "Military Explosives and Ballistics."

22. The university to take steps to establish a tailor shop for the alteration and fitting of uniforms.

This will be necessary for altering the issue uniforms in order to obtain neat and comfortable fits. It must be remembered that the students are growing and what fits them well one year may be uncomfortable the next. There is no provision for alterations at present, and this is probably the reason that so many students wear their uniforms unbuttoned—they are too tight for comfort. The student will probably have to bear the expense of alterations. The system should be handled so that the cost to the student will be the lowest possible.

Note:—The above suggestions apply primarily to an infantry unit. They may, however, be adapted to any unit, making such changes as are necessary to comply with War Department orders.

Nothing has been said in this paper about establishing particular kinds of units. It may be taken for granted that at most institutions of the Land Grant class only infantry units will be established. These units are easier to establish, are less expensive than others—considerably less expensive than mounted units—and require fewer facilities. Any institution that desires to establish other units will have to show especial facilities for training them. Since infantry units are those most likely to be established, it follows that the institution that wants to take the lead in this matter should not be content only with an infantry unit, but should secure any other units adapted to the facilities of the university.

CONCLUSION

It may be stated that military men regard any form of military training—other than universal service—as a makeshift. The Reserve Officers' Training Corps then, from their point of view, is a makeshift. Nevertheless it offers certain opportunities for effective results. The degree of proficiency is largely in the hands of the university. The law provides a certain mechanism, but unless that mechanism is used to the best advantage results will be negligible. A liberal interpretation of the intent of the law, applied along constructive lines, will convert what is called a *makeshift* into an adequate military training, and the institution that desires to attain the best military results—coincident with educational results—must work along such constructive lines—must lead, not follow.

PROFESSIONAL NOTES

EROSION OF GUNS—THE HARDENING OF THE SURFACE

By HENRY FAY,[1] Ph. D., D. Sc., Cambridge, Mass.

(New York Meeting, American Institute of Mining Engineers, February, 1917)

The erosion of guns is a complex problem which can be solved only by a detailed study of all the factors involved. In the present paper it is proposed to submit the results of observations and experiments which have extended over several years. Certain facts have been established and preliminary reports have been published.[2] Conclusions have been reached since then which, it is believed, are worth presenting for the purpose of promoting discussion, and with the hope that ultimately the whole truth will be known. The particular phase of the problem which will be presented here is the hardening of the inner surface of the gun tube.

It has been known for a long time that after firing a large caliber gun for some time, the surface of the metal becomes hard and brittle, cracks, and wears away.[3] The character of this phenomenon may be learned by an examination of some results which are typical, obtained from a detailed study of a 12-inch gun. The gun was trepanned and rings representing various sections of the gun were cut out for examination. The first ring represented the metal at the muzzle end, and the other rings were removed at approximately 120, 240, 325, and 337 inches, respectively, toward the breech end.

The appearance of the surface of the metal in the different sections is shown in Fig. 1. The greatest amount of wear and maximum amount of hard surface layer was found in section marked *E*, which is nearest the powder chamber and at the beginning of the rifling; the maximum amount of cracking in *D;* the maximum amount of copper deposition in *C*. Section *B* showed heat cracks on both lands and grooves, and section *A* showed heat cracks *on the driving edge of the lands only*. There was much flow of metal in both sections *E* and *D*, and there was progressively less effect noticeable toward the muzzle end. The polished cross-section of these same pieces is shown in Fig. 2. The extent of the erosion is greatest nearest the powder chamber, and diminishes toward the muzzle end.

The depth of heat crack varies irregularly in each section, and somewhat regularly in sections proceeding from *A* to *E*, increasing in depth toward the powder chamber. The number of cracks does not, however, vary in the same way. In section *E*, where the greatest erosion has taken place, the smallest number of cracks appear.

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[1] Professor of Analytical Chemistry, Massachusetts Institute of Technology.

[2] Tests of Metals, Watertown Arsenal, 1913 and 1914.

[3] This action is not confined to large caliber guns exclusively but will occur also in smaller guns, although, as will be shown, the action is much accelerated with the increase in the weight of the projectile.

The greatest depth of crack is found in section *D*, with an average depth of 0.038 in. The width of crack in this section varies between 0.001 and 0.015 in. In section *E* the depth varies between 0.024 and 0.039 in. In section *C* the average depth of crack is only a trifle less than in *D*, but the width is not nearly so great. The cracks diminish progressively in depth and width in sections *B* and *A*, the latter section showing practically no cracks on the face normal to the axis of the gun. On a face parallel to the axis of the gun and cut along the driving edge, section *A* shows some clean, sharp cracks about 0.01 in. in depth.

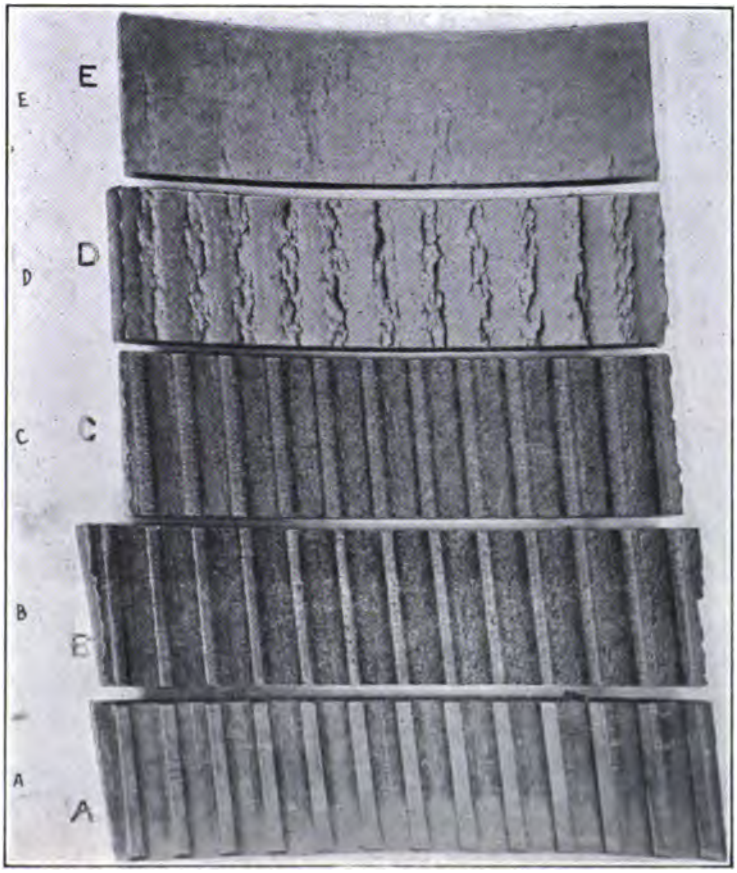

Fig. 1. 2043

Sections *B*, *C*, *D*, and *E* show a hard layer of metal on the face cut normal to the axis. All five sections show the hard layer on the face cut parallel to and along the driving edge. The depth of the layer of hard metal on the face normal to the axis varies as follows: *A*, 0.0000 in.; *B*, 0.0004 in.; *C*, 0.0008 in.; *D*, 0.0013 in.; *E*, 0.0015 in.

The cracks are undoubtedly due to the unequal expansion and contraction between the hard and soft layers. When subjected to strain the hard, brittle surface develops cracks, and the cracks penetrate into the soft metal. The section showing the greatest thickness of hard layer ought to show the greatest depth of crack, but other influences counteract this effect.

The microscopic appearance of a surface showing cracks is shown in Fig. 3, and in Fig. 4, the latter a characteristic structure always found at the junction of a land and groove. The interpretation of these photographs will be considered in detail after discussing the cause of the formation of the hard layer. In addition to the hardening which takes place in the gun tube proper, hardening and cracking of the surface takes place on the pressure plugs which are inserted in guns for the purpose of measuring maximum powder pressures. The pressure plug shows hardness around the edge of the central hole, around the edge of the plug itself, and shows the effect of hardening in the form of cracks all over the surface, but particularly in the vicinity of letters which have been stamped on the surface. Any theory which may be offered to explain the hardening of the gun tube proper must also explain the hardening and cracking of the pressure plug.

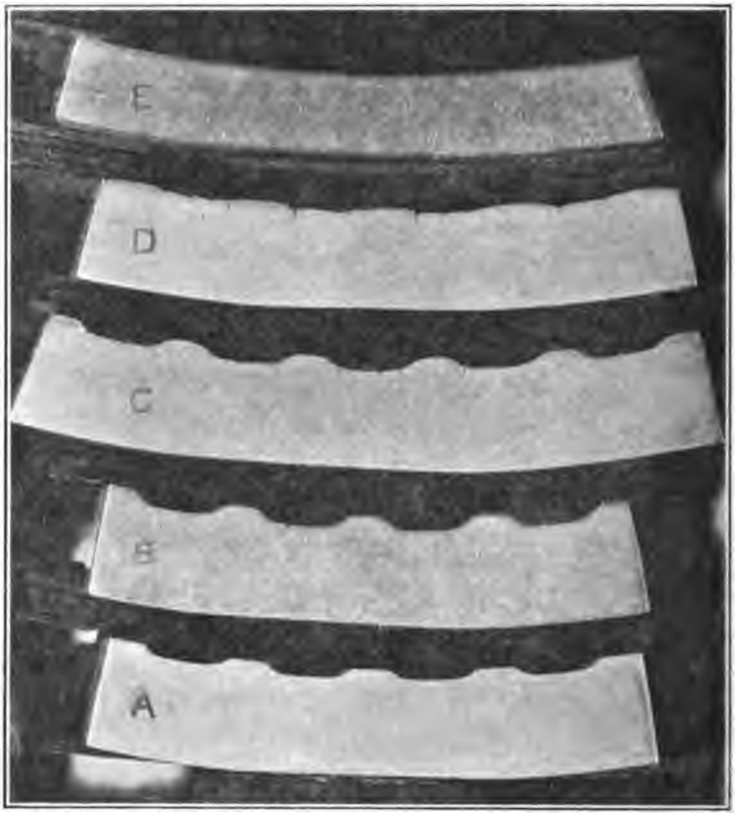

FIG. 2. 9044

While these results are in general typical of what takes place, there are variations in individual cases. For instance, the metal on the driving edge may not have been affected as it was in the 12-in. gun referred to, but it is merely a matter of time until the conditions as described are obtained. The action is a progressive one and is dependent upon the number of times the gun is fired.

The Cause of Hardening

Hardening may be produced by three well-defined methods: (1) cementation; (2) heat treatment; (3) mechanical deformation or cold work.

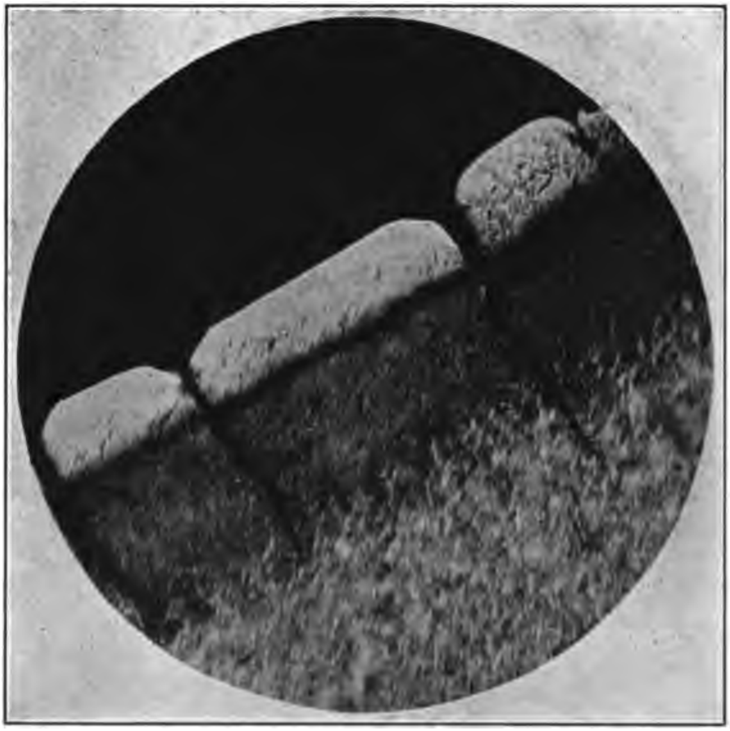

Fig. 3.—×50 2966

CEMENTATION

The principal products of combustion of the powder are carbon dioxide, carbon monoxide, water, and nitrogen. The equilibrium phenomena are very complex and will vary with the composition of the powder, the temperature and pressure. It is conceivable, however, that large amounts of carbon monoxide may be formed, and under the conditions of high temperature and pressure cementation could take place. Giolitti[1] has shown carbon monoxide to be an ideal carburizing compound, and on repeated firings small increases of carbon to the surface might take place. This would produce a hard, brittle layer on the surface richer in carbon than the original metal.

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[1] *Journal of the Iron and Steel Institute*, vol. 84, p. 307 (No. 2, 1911).

HEAT TREATMENT

When a piece of steel is heated above its critical temperature, Ac_1, and then suddenly quenched, it is hardened, the depth of hardening being dependent upon the temperature of heating and the rate of cooling. The temperature of combustion of the powder is sufficiently high to heat a skin of the metal above the Ac_1 point, and hardness would result if the surface were coöled with sufficient rapidity. The relatively low temperature of the large mass of steel would produce a rapid loss of heat.

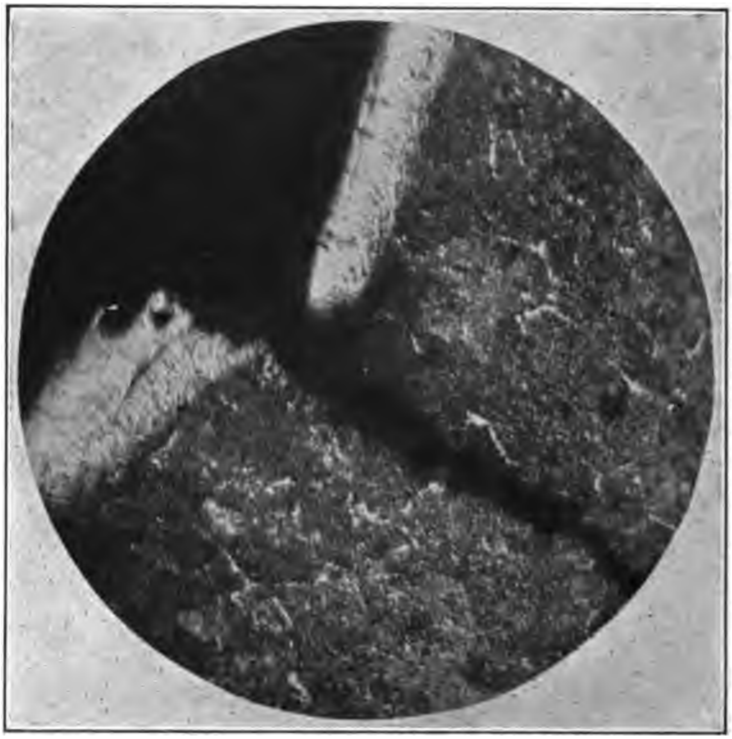

FIG. 4.—X50 2046

MECHANICAL DEFORMATION OR COLD WORK

It is a well-known fact that when any ductile metal is subjected to mechanical deformation it becomes hard and brittle, and if the work is carried too far, cracking will result. Even the most ductile metals, such as gold and platinum, lose their plasticity and become hard and brittle when subjected to drawing, hammering, etc. In wire drawing it becomes necessary to anneal the metal frequently in order to restore plasticity and prevent it from cracking. This phenomenon is common to both ductile and brittle metals.

The mechanism of this action has been studied in detail by Beilby[1] and his conclusions have been confirmed and accepted by many other investigators. According to him, a surface skin may be built up by mechanical movement which gives unmistakable evidence that the surface must have passed through a state in which it possessed the perfect mobility of a liquid. This surface possesses distinctive properties which differentiate it from the surface beneath it. Hardening thus results from the formation at all the internal surfaces of slip or shear of mobile layers similar to those produced on the surface by mechanical movement. These layers retain their mobility for a brief period only, and then solidify in a vitreous amorphous state cementing together all of the surfaces of slip or shear throughout the mass.

Such a surface produced by polishing, burnishing, drawing, hammering, or cold work of any kind, possesses the property of hardness and brittleness. Metal in this condition may be restored to its natural crystalline, ductile state by annealing.

THE SORBITE–TROOSTITE–MARTENSITE TRANSFORMATION

Having considered the manner in which hardness may be produced, it becomes necessary to examine the different methods in detail, and to see by which method the facts can best be explained. It would seem at first sight to be rather difficult to prove whether or not cementation had taken place, as the maximum thickness of layer which had been hardened amounted to only 0.0015 in. It was obviously impossible to cut off this layer for analysis, not only on account of the thinness, but also on account of the hardness.

Microscopically the appearance of this surface suggested cementite, as it remained bright after etching, as shown in Figs. 3 and 4, and, furthermore, in no case was there any evidence, even under high power, of martensite, which would also remain brighter than the original structure. Etching with boiling sodium picrate, which darkens cementite, gave negative results. The hardness of the layer and its appearance would indicate free cementite, but this test would, therefore, appear to be conclusive that the surface cannot contain any free or excess cementite. The test was carried out always with a control piece which contained about 1.25 per cent of carbon, and therefore known to contain free cementite. Under all conditions the control gave positive results. There is some doubt as to whether or not a small amount of cementation takes place, and experiments are in progress which, it is hoped, will prove this point definitely.

While it seems fairly clear that the hard surface layer is not free cementite, judging from the sodium picrate test as evidence, it would have been difficult on this basis to explain the fact that the hard layer occurs only on the driving edges in the muzzle end of the gun. Selective formation would not seem probable.

That hardness might be produced by raising the temperature above Ac_1 and suddenly cooling seems entirely possible, and most of the facts can be explained on this basis. The temperature within the gun at the time of the explosion is far above Ac_1, in fact may be above the melting point of the metal. A thin skin of metal is heated for a brief period during the explosion, and before the heat can penetrate any distance, it is cooled by the mass of metal back of this layer. Such a hardening ought to produce the microscopic constituent martensite, but this structure in its characteristic needle-like form is never found, although troostite is frequently found. Rosenhain[1] and Belaiew[1] have reported martensite in the hardened surface of the rifling of a gun, but so far in the examination of many gun fragments, and in trepanned guns, the characteristic martensitic structure has been missing. In some experimental steels which had been subjected to erosion tests by allowing the gas of an ignited charge of powder to escape through a tube of the metal, there was found not only well-characterized martensite but also troostite adjacent to it. The essential difference in this case is that there was no projectile to produce mechanical deformation on the surface.

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[1] *Journal of the Institute of Metals*, vol. 6, p. 5 (No. 2, 1911).

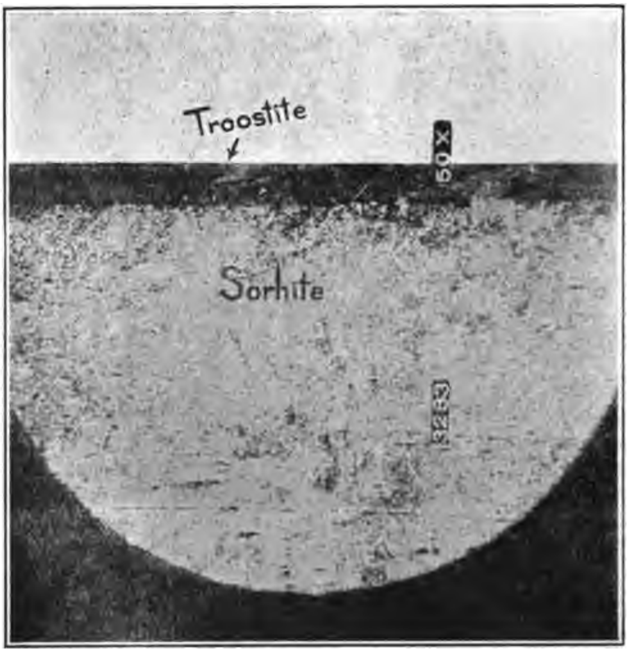

FIG. 5.—X50. 2047

That the hard surface is actually composed of martensitic material is proved by the fact that on tempering it passes over to characteristic troostite. Samples were cut out of the ring from section *E*, and heated for 15 min. to 300°, 400°, 500°, 600°, and 700°. The specimen heated to 300° showed troostite development most markedly and unmistakably, as shown in Fig. 5. The 400° and 500° samples also showed troostite, but less well defined, the transformation having progressed further, and there was almost complete reversion in the specimens heated to 600° and 700°. This experiment seemed to prove conclusively that the hard surface was martensite, but threw no light upon the fact that in the muzzle end of the gun the surface was hardened *on the driving edge only*.

It was thought for a time that mechanical deformation or cold work produced by the rotating projectile would account for all of the phenomena, but this idea was negatived by (1) the martensite—troostite conversion; (2) by the fact that the powder chamber itself, untouched by the rotating projectile, showed hardness; (3) and by the fact that the pressure plug showed hardness.

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[1] Rosenhain, Belaiew: International Association for Testing Materials, New York, 1912, *Proceedings*, vol. 2, section A, p. 127.

That mechanical deformation has much to do with the production of hardness is shown by the selective hardening on the driving edge of the land on the muzzle section, and by some experiments which were conducted on pressure plugs.

Knowing that pressure plugs harden in the same way as the surface of the gun tube itself, it was decided to experiment with pressure plugs, and to follow the development of the hard surface layer in its various phases. For this purpose, a plug having approximately the same composition as gun steel was prepared for service. The metal was carefully analyzed, it was heat treated, and photographs were made of the fine sorbitic structure. The surface as a whole was uniform. The prescribed lettering was stamped on the surface. It was then placed in service, and after having been fired until it showed signs of heat cracking, was returned for microscopical examination. The face was polished and etched, and the structure seemed to be normal, but it was seen on detailed examination that the hard surface had begun to appear on the edge of the center hole and on some of the letters. Examination showed that this development had taken

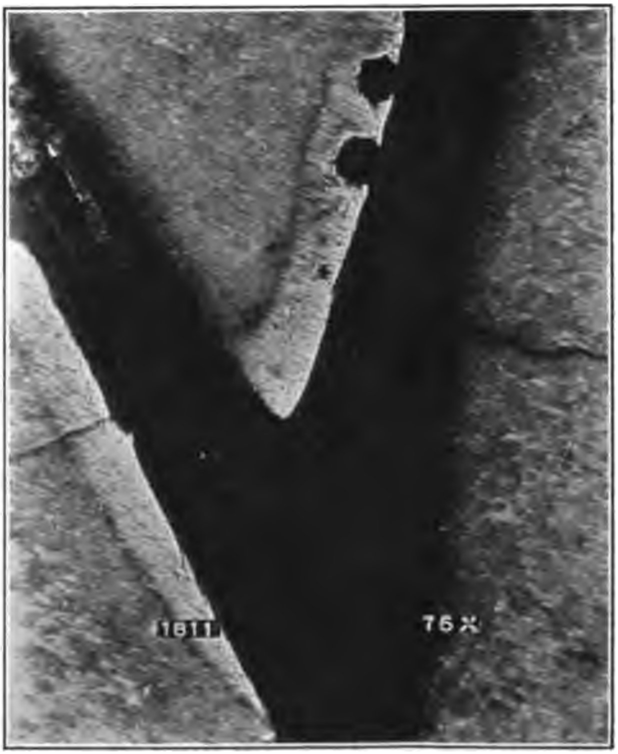

FIG. 6.—X75 2046

place at those points where the *maximum amount of cold work had been applied in stamping the letters*. This is shown in Figs. 6, 7, and 8, representing the letters A, O, and a period respectively. In the letter A and in the period the die was apparently not held in a truly vertical position and one side of the letter was cold-worked more than the other. Selective conversion of soft to hard metal has taken place at these points. This is shown in the lighter area of Fig. 6, and also of Figs. 7 and 8, the light area in each case being the hard area. Observations of a similar character were made on almost every letter on the face of the pressure plug, each showing partial conversion from soft to hard structure at the point of maximum cold work.

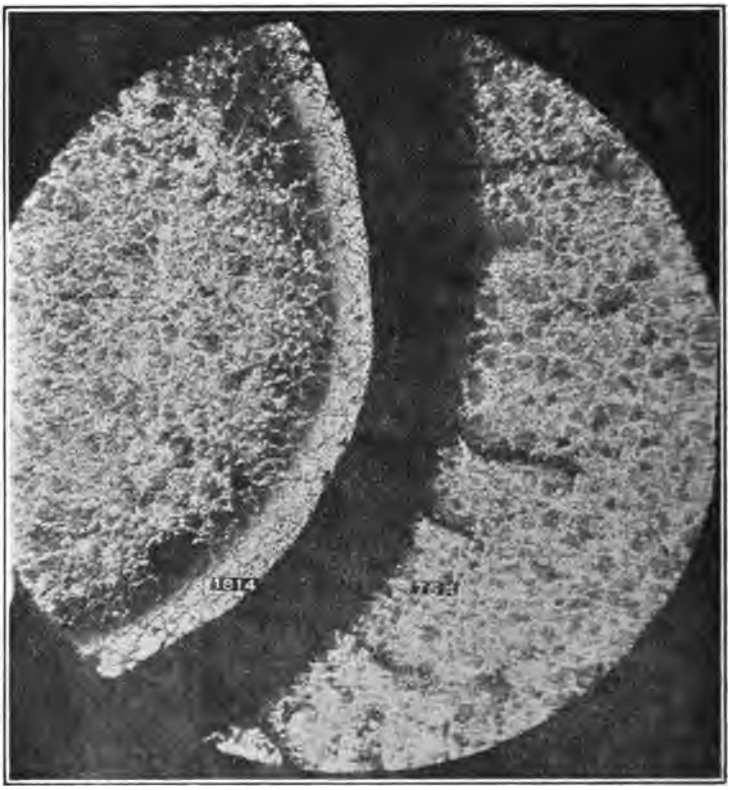

FIG. 7.—X50 2049

This evidence seemed to favor the view that cold work was an important factor in the martensitization[1] of the metal.

In order to test this view systematically, a second pressure plug was prepared and the letters V and O were stamped on the face of the plug at varying pressures. This was done by holding the stamping die in one jaw of a tensile testing machine and the plug in the other jaw. The machine was now put into compression and the letters stamped at varying pressures, from 500 to 2000 lb., as shown in Fig. 9. By mistake, one of the letters V was stamped at 5000 lb. instead of 2000 as originally intended.

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[1] The process of producing hardness by converting the free iron carbide into solid solution of iron carbide in iron. This is commonly done by quenching the steel from above Ac_1.

The pressure plug was then put in service and the gun was fired 100 rounds, when the plug was returned for examination. The original sorbitic condition of the metal was found to have changed to the troostitic condition at those points of maximum cold work and to have remained practically unchanged at other points. Thus the first step in the change: sorbite—troostite—martensite had been accomplished.

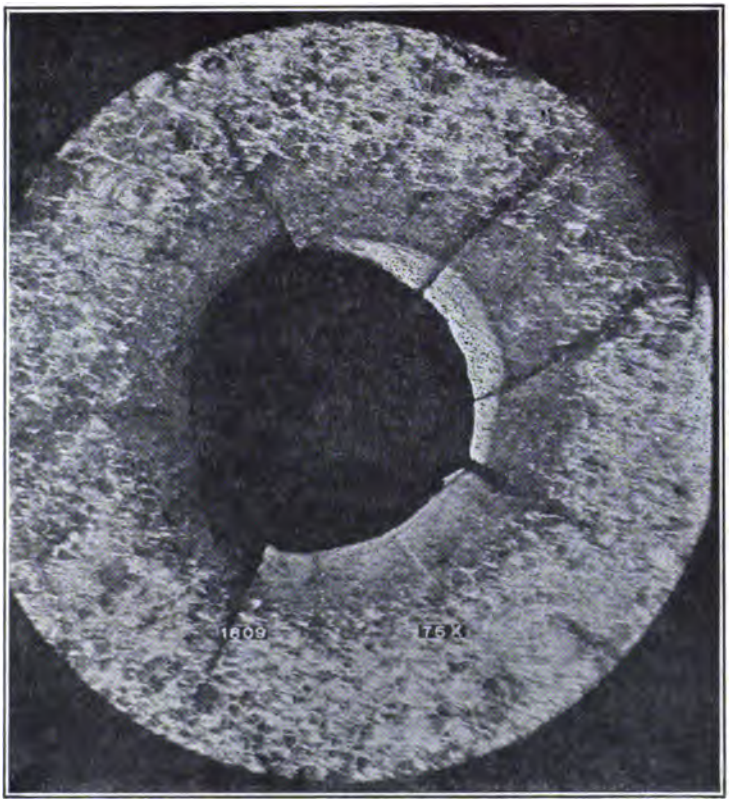

FIG. 8.—X50 2050

Figs. 10, 11, 12, and 13, show the letter V at 5000, 2000, 1500, and 1000 lb., respectively. In Fig. 10, the troostitic character of the metal is clearly shown on the edge and apex of the letter V. The letter impressed at 2000 lb. also shows the change, but not advanced so far as in the letter of greater pressure. At 1500 lb. the change has begun but the advance has not been far, and at 1000 lb. pressure the change is not noticeable.

In the same plug similar changes were noticed on the edge of the central hole, on the outer edge of the plug, and on two periods stamped at an angle of 45°. The period was strongly cold-worked on one side and the change was well-marked.

The plug was again placed in service for 100 rounds and then returned for examination. The result is shown in Fig. 14, which is the letter V impressed at 5000 lb. It will be noticed that the transformation has proceeded to its final stage, viz., the light etching structure which had previously been shown to be martensite.[1]

These experiments seem to prove that the hardness of the surface of a gun tube as well as the pressure plug is due to a combination of mechanical deformation and a process of martensitization. This process requires time, and the development takes place in stages. Even in the early stages there was evidence of heat cracking before the change of structure had taken place. When the structure begins to change it first shows as troostite, and then develops into martensite, but the latter is amorphous[2] in form. Temperature and work are also important factors. The transformation takes place with the greatest rapidity where the work has been most severe.

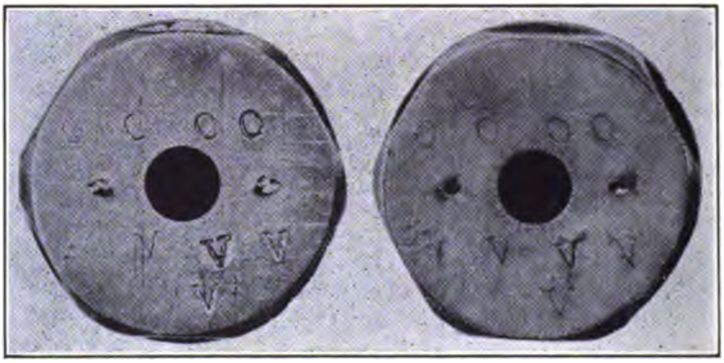

Fig. 9.—Pressure Plug Before Having Been Placed in Service and the Same Plug After Having Been in a Gun Which Had Been Fired 100 Rounds.

The surface of the metal (right) has been worn away by some volatilization of the metal and by the polishing necessary to produce the structure.

These factors counterbalance each other in the gun to a certain extent. In the powder chamber there is the maximum temperature, but the minimum amount of work. The only work which has been done upon the metal here is the original machining of the gun. In section *E* where the rifling begins, the maximum amount of cold work is done. The rotating band is undeformed and the whole surface bears on the rifling. This is also true of section *D*, but in each section toward the muzzle there is a decreasing amount of work due to the grooving of the rotating band until at the muzzle end the driving edge alone receives work.

The reason that a cold-worked metal is more susceptible to the sorbite—troostite—martensite change when exposed to firing is not clear. There may, however, be two factors at work: Beilby has shown that mechanical deformation of any kind produces an amorphous state in the metal, and it is entirely possible that the amorphous metal may be more sensitive to the reaction, *i.e.*, it may have greater solvent power for iron carbide. He has shown, and many others have confirmed the observation, that such metal has a greater solution pressure and it is possible that it may have greater dissolving power for iron carbide.

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[1] There seems to be a difference in the degree of magnification of Figs. 10 and 14, but this is due to a wearing away of the metal by volatilization and polishing, thus exposing the deeper and narrower part of the groove of the letter.

[2] Capable of being easily converted into troostite, but showing none of the characteristic needle structure.

Spring has shown that certain reactions, which ordinarily take place when under the influence of heat, can be made to take place at the ordinary temperature when under the influence of pressure. Thus he caused dry sodium carbonate to react with dry barium sulphate with the formation of sodium sulphate and barium carbonate. He also caused powdered zinc

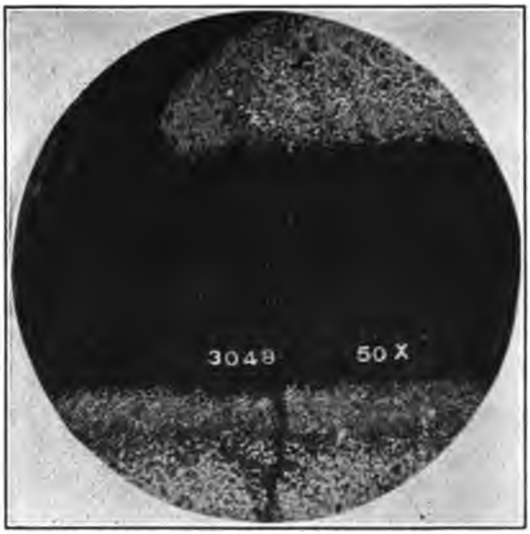

FIG. 10.—LETTER V IMPRESSED AT 600 LB. ×60 3062

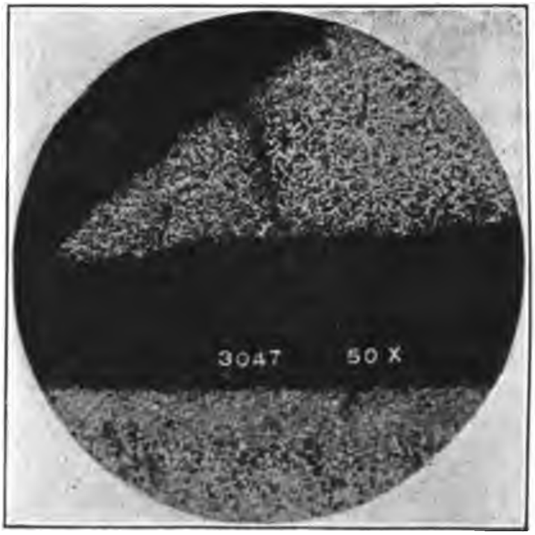

FIG. 11.—LETTER V IMPRESSED AT 2000 LB. ×60 3063

to alloy with finely divided copper to form brass. In each case precautions were taken to eliminate any heat effects.

In a gun the original metal is sorbitic and the iron carbide is therefore mostly in the free form, only a minimum amount being held in solid solution. When subjected to the pressure of cold work, or the pressure of the explosion at a high temperature, solution may take place, each round of firing adding to the amount which goes into solution. This would lead

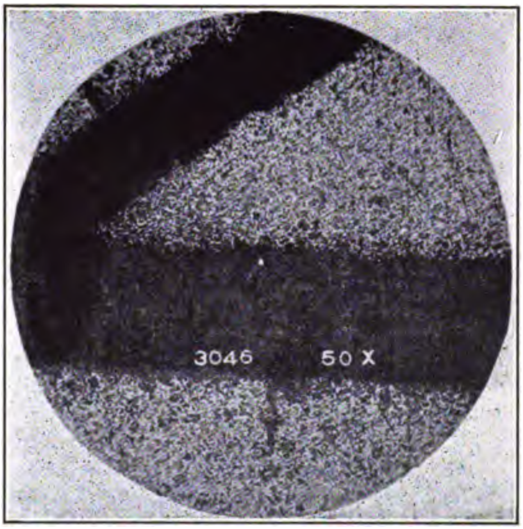

Fig. 12.—Letter V Impressed at 1500 Lb. ×50 2054

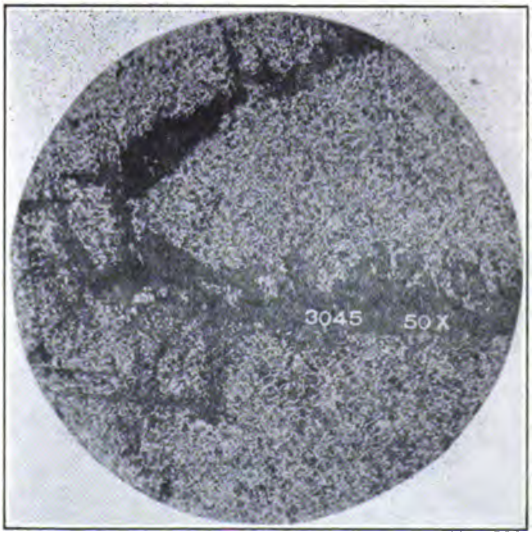

Fig. 13.—Letter V Impressed at 1000 Lb. ×50 2055

naturally to the formation, first, of troostite, and when the solution is complete, of martensite. These steps are actually observed.

Either hypothesis—solution in amorphous metal, or solution by pressure—may explain the phenomena observed, but the latter seems the more likely. This would more adequately explain the fact that in erosion tests of steels of various composition, those steels high in nickel or manganese show the greatest amount of martensite formation. In these steels the Ar_1 point is lowered slightly, thus increasing the tendency for the carbon to be held in solid solution form. Thus, in one case, a 3.50 per cent nickel steel showed a martensite surface 0.05 in. in depth, while under exactly similar conditions a plain carbon steel showed only 0.004 in. Nickel and manganese lower the Ac_1 point, and hence make it easier for the sorbite—troostite—martensite transformation.

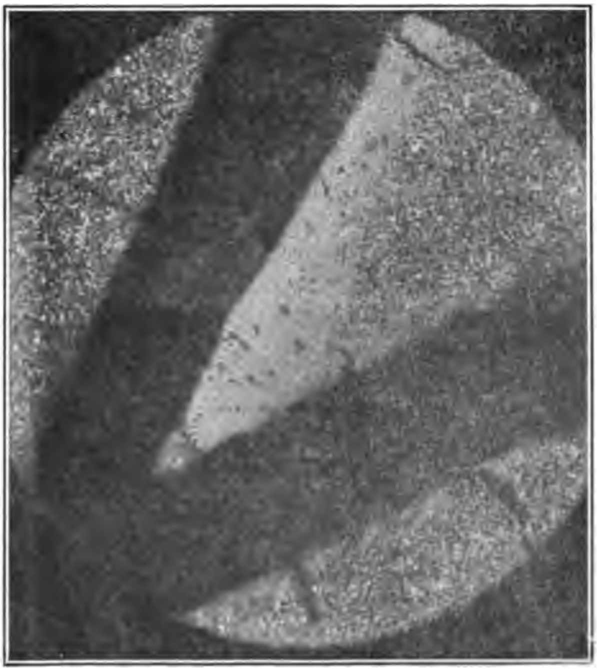

FIG. 14.—LETTER V SAME AS SHOWN IN FIG. 10, BUT AFTER FIRING 200 ROUNDS. ×50 2056

Experiments are now in progress with alloy-steel pressure plugs to see whether or not the hard surface develops more rapidly with them than with plain carbon steels. It is highly probable that those steels having the highest Ac_1 point will show hardening the least rapidly. A convenient means of testing this is to make up a series of steels into the form of small screws, stamp some letter at 5000 lb. pressure, place them in the mushroom head of the breechblock, and make observations after firing.

The preceding work was carried on at the Watertown Arsenal and the writer wishes to express his appreciation of Colonel Wheeler's interest and his courtesy in allowing the data to be published.

—*Transactions of the American Institute of Mining Engineers.*

THE MILITARY VALUE OF COAL AND IRON

Sir Robert Hadfield sends us a very interesting translation which he has had made of an article which appears in a German newspaper under the caption, "What Our Sword Has Gained." It follows one of a series written by Privy Councillor (Prof. Dr. Schumacher), who discusses, in a fairly long series of articles, the value and importance to Germany of the "conquered Belgian kingdom." The present article deals with the French territories still occupied by Germans, and is written by Dr. M. Schlenker, of the Saarbrücken Chamber of Commerce. Dr. Schlenker writes as follows:

Regular readers of French newspapers will find that public opinion in France has lately been occupying itself in a greatly increasing measure with the importance of the French Lorraine iron-ore district. Thus, Senator Berenger, the Secretary of the National Defense Committee of the Senate, after coining the phrase: "In this war, iron is king," has pointed out that Germany's main purpose in the thrust against Verdun was to secure her hold on the Briey iron-ore basin; that the purpose of the savage submarine war was, above all, to deprive France—which through the occupation of the Briey basin had already lost 90 per cent of its iron-ore—also of supplies of iron from abroad. The ore basin of Briey, we may read again and again in the French papers, *is the battlefield on which France and Germany are fighting for the dominion of iron.*

This recognition may be a contributory element towards the fact that Verdun plays an exceedingly important part in French popular sentiment. It cannot be denied that the sons of France—Verdun having been represented to them as being the cardinal point of the ore supply of France—are fighting with great heroism for the preservation of this foundation of power and strength. The possession of iron-ore, the recognition, the will and the power of the use thereof—*these are the prerequisites of liberty, because they are the foundations of the development of strength and power.* Iron bestows liberty, for "God, who made iron grow, did not will men to be slaves."

In his publication, "War and the Mining Industry," Professor Max Krahmann, Lecturer on "Mining Economics" at the Royal Academy of Mining, Berlin, demonstrates convincingly the intimate relations existing between iron-ore and coal and war. He actually designates the war now raging as the "Coal and Iron War in Europe," and predicts a future *real* world war, in which East Asia and North America will take part, and which will have to decide definitely which coal and iron countries shall take the lead in future. No doubt, in view of the pre-eminent importance of the mining industry in war, the predominant factor in any future decision will be the conditions of strength of the belligerents in respect of heavy mineral products.

After these introductory remarks Dr. Schlenker prefaces a discussion of the economic importance of the French Lorraine ore basin by a summary of the "Iron-ore Reserves of Europe." The available reserves of iron-ore in Europe, according to a statistical summary recently published by the North-Western Group of the Association of German Iron and Steel Manufacturers in Düsseldorf, are as follows, in millions of tons:

	Proved ore reserves			Anticipated ore reserves		
	Ore	Per cent of total proved ore reserves	Metallic iron	Per cent of total proved ore reserves	Ore	Metallic iron
The German Customs Union	3877.7	31.4	1360.0	28.8	considerable	considerable
France	3300.0	27.4	1140.0	24.0	--	--
Belgium	62.0	0.5	25.0	0.5	25.0	10.0
Great Britain	1300.0	10.8	455.0	9.8	37700.0	10830.0
Sweden	1158.0	9.6	740.0	15.6	178.0	105.0
European Russia	864.6	7.2	387.2	8.2	1056.3	424.7
Spain	711.0	5.9	349.0	7.3	considerable	considerable
Norway	367.0	3.0	124.0	2.6	1545.0	525.0
Austria	250.9	2.1	90.4	1.9	323.2	97.0
Hungary	33.1	0.3	13.1	0.2	78.9	34.1
Total Europe	1184.3	--	4683.7	--	40906.4	12025.8

Out of the proved reserves of iron-ore (metallic iron) the following percentages fall to the share of Germany and France respectively:

	Germany Per cent	France Per cent
The European deposits	28.8	24
The World's deposits	13.0	11

Hence France comes very near to Germany.

THE OUTPUT OF IRON-ORE

This amounted in 1913, for the whole world, to 160,393,000 tons, divided as follows:

	Tons	Per cent
United States	62,972,000	39
Germany and Luxemburg	35,941,000	22
France	21,500,000	13
Great Britain	16,254,000	10
Spain	9,861,000	6
Sweden	7,479,000	5

The ore supply of Germany for 1913 was as [indicated at top of next page].

Hence 44 per cent of the contents of iron in the ore came from abroad. Germany imported from France 1,410,000 tons, or 18.29 per cent of the total.

The output of ore in France in 1913 amounted altogether to 21,500,000 tons, of which in the Department of Meurthe-et-Moselle 19,800,000 tons were produced. In particular, in the Briey basin 15,000,000 tons were

	Quantity of ore	Iron contained
	Tons	Tons
Output	35,941,000	10,541,500
Imported	14,019,000	7,710,400
Total	49,960,000	18,251,900
Exported	2,613,000	783,900
Home consumption	47,347,000	17,468,000

mined, containing metallic iron to the amount of about 5,000,000 tons. The output in the Briey basin of ore, containing 5,000,000 tons of iron, equalled about 67 per cent of the German imports of metal and 28 per cent of the German supply of metallic iron. The following table will show in what a great measure the importance of the ore basin of Longwy-Briey as a source of supply of ores for Germany has been increasing:

Imports of Iron-Ore Into the Territory of the German Customs Union from France

Year	Ore imported	Iron contained	Per cent of total ore imports	
			Ore imported	Iron contained
	1 = 1,000 tons	1 = 1,000 tons	1 = 1,000 tons	1 = 1,000 tons
1901	45.6	16.6	1.04	0.65
1905	280.2	103.6	4.60	3.09
1910	1773.8	656.3	18.07	12.15
1911	2122.9	785.4	19.62	13.19
1912	2692.0	996.0	23.21	14.94
1913	3810.9	1410.0	27.18	18.29

The really phenomenal growth of the supplies of iron-ore obtained by Germany from the Longwy-Briey basin will be particularly evident from a comparison with supplies from Spain and Sweden, which have hitherto been the chief purveyers for Germany. The imports of iron-ore from these two countries in thousands of tons are shown in the following table:

Year	Spain		Sweden	
	Ore imported	Iron contained	Ore imported	Iron contained
1901	2136.6	1068.3	1477.1	886.26
1905	3163.8	1581.9	1642.5	985.5
1910	2861.2	1430.6	3249.0	1949.4
1911	3154.4	1577.2	3502.2	2101.32
1912	3726.2	1863.1	3875.1	2325.06
1913	3632.1	1816.05	4558.4	2735.04

The following table expresses the same figures in percentage of the total imports of iron-ore:

Year	Spain		Sweden	
	Ore imported	Iron contained	Ore imported	Iron contained
1901	48.89	44.45	33.80	36.87
1905	51.99	47.25	26.99	29.45
1910	29.15	26.49	33.10	36.15
1911	29.15	26.50	32.36	35.31
1912	30.74	27.95	31.96	34.88
1913	25.91	23.55	32.52	35.47

The imports of iron to Germany from Spain have entirely ceased since the outbreak of the war.

Dr. Schlenker proceeds to remark that there is no need of further argument to show that Sweden was not, and could not be, in a position to make good the deficiency arising thereby of 23.55 per cent; and continues: "It must therefore be described as a special stroke of good fortune that at the very commencement of the war Germany came into possession of the Briey ore basin, as without the French iron-ores it would have been impossible for the German iron industry to cover our own and our Allies' enormous requirements of munitions. Further, the great advantages which come to us from the occupation of the ore basin mean the reverse for France." As already shown above, the share with which the Department of Meurthe-et-Moselle participated in the total extraction of iron-ores in France in 1913 was no less than 19,813,572 tons, whereof again the greater part came from the Briey basin, where the extraction of ores in 1913 soared up to 15,023,740 tons.

Seeing that even the iron mines in the districts of the Department still held by France, and which are situated chiefly in the neighborhood of Nancy, are scarcely likely to have remained at work, France has lost, through the occupation, no less than roughly 90 per cent of her normal output of iron-ore, or, if we make allowance for the higher percentage of metal contained in the other French iron-ore, fully 85 per cent.

According to a report submitted by Dr. Schröder, of Düsseldorf, on January 31, 1915, to the general meeting of the Association of German Metallurgists (Verein Deutscher Eisenhüttenleute) no less than 95 of the roughly 127 blast furnaces which were in blast at the commencement of 1913 out of the 170 altogether existing in France, are situated in the war zone, and even the furnaces situated behind the trenches are scarcely likely to have been kept in blast in view of the shortage of ores and the existing conditions in general, so that only some 30 blast furnaces remain which could continue to work uninterruptedly. As the later number includes some small furnaces of 30 to 60 tons daily output, while the large furnaces are situated mainly in the East of France, at least 80 per cent of the entire pig-iron production of France is likely to have been stopped by the war, and more especially by the rapid thrust forward beyond the Briey ore basin.

But in appreciating the importance to us of the present possession of the ore basin, we must not only think of the production of munitions; a circumstance of quite inestimable value to us was that we were not only able to cover our own and our Allies' extraordinarily increased requirements of iron, *but were also, above all, in a position to export to neutral countries goods produced by means or with the aid of iron and coal, partly by way of exchange for commodities which were most important to us,* and thus to support our economic strength and our power of resistance. It will be interesting to verify, after the war, the view that a country which commands unlimited quantities of iron-ore and coal, *remains simply invulnerable in its most important sources of strength and power.*

—*Iron and Coal Trades Review.*

◆ ◆ ◆

TEST OF RADIO TELEPHONE OF AEROPLANES

For the first time in the history of American aeronautics radio-telephonic communication between a military aeroplane in flight and a land receiving station today was established at the Signal Corps Aviation School at North Island.

The tests held under the joint supervision of Captain Clarence Culver, holder of the world's record for long distance radio aeroplane communication, and E. J. Simon, New York radio engineer, were a pronounced success, according to officials of the school.

Flying at an altitude of 800 feet in a tractor biplane pilotted by Captain Herbert Dargue, Captain Culver succeeded in transmitting several verbal messages a distance of approximately three miles. Captain Culver's voice came floating out of the blue sky as clear and distinct as though he was but a few feet distant from the receiving room.

Trouble was encountered with the belt of the aero fan, slung underneath the fuselage, when, traveling at 85 miles an hour, the suction of the wind caused the belt to slip off. The aero fan is to be supplanted by a quarter kilowatt generator driven by a two blade propeller fastened to the lower wing section.

Within the next ten days Captain Culver and Mr. Simon expect to have little difficulty in engaging in extended conversation while flying in two distinct aeroplanes many miles apart. The War Department has set aside two Martin military tractors for radio telephonic experimentation.—From *N. Y. Herald* in *Proceedings of the U. S. Naval Institute.*

BOOK REVIEWS

A Primer for the Officers' Reserve Corps and Officers of the Volunteers and National Guard, U. S. Army. By Captain Robert R. Welshimer, Coast Artillery Corps, U. S. Army. Illinois: The University of Illinois Supply Store, Champaign. 6"x 8¾". 113 pp. 7 il. Paper. 1917. Price, $1.00.

With the prospective expansion of the land forces of the United States at an early date, there will be a great demand for military books for military students. Based upon his experience at the University of Illinois, Captain Welshimer undertakes to instruct the student by means of catechisms on several subjects. He attacks the essentials of the following subjects and supports his method by illustrations where necessary to illumine the answers: Information concerning the Officers' Reserve Corps; military law; U. S. magazine rifle, model 1903; small arms firing; tables of organization; map reading; military sketching; field service regulations, including information, advance guards, patrols, marches, shelter; company administration; field artillery matériel; coast artillery matériel; explosives; hippology; guard duty.

This pamphlet should be of great value to the beginner; it should also aid an instructor in outlining a course. It is a hurried compilation based upon several official publications, and has the immediate advantage of being right up-to-date on the topics covered. While this book is merely an introduction to a new officer's education, it should give him a good start, at least. Used in conjunction with the several official publications, it starts the beginner on the essentials and rounds out a good preliminary course.

◆ ◆ ◆

Notes on Military Explosives. (Fourth Edition, Revised and Enlarged.) By Erasmus M. Weaver, Major-General, Chief of Coast Artillery, U. S. Army. New York: John Wiley & Sons, Inc., 432 Fourth Ave. 9¼" x 6". 371 pp. and index. 23 il. 1917. Cloth. Price, $3.25.

In view of the early participation of the forces of the United States in the European conflict, with the use of explosives by all branches, the fourth edition of this reference book comes from the press at an especially opportune time. The matter has been brought up-to-date, and the new issue makes the work available to the new armies.

Every branch will need to know something at least about the properties of the explosives it is using—the bombers as well as the engineers and artillerymen. The better this knowledge is, the better will be the care of the ammunition in storage and transport, and fewer will be the easily avoidable accidents which are bound to occur where powerful agencies are handled ignorantly. One of the principal values of this book is that it collects the necessary information under one cover. By an expert in the science, it brings to the soldier of the line the elements of the subject in clear, concise form.

The early chapters deal with the elementary part of chemistry, in order to clarify the theory of the subject for the beginner and give simple, thorough instruction preparatory to an understanding of the chemistry to follow.

Having grasped sufficient of the theory, the next chapter deals with the substances used in the manufacture of explosives—their sources and natures and significances.

Then follow discussions as to the different forms of explosions, different types of explosives, manufacture of explosives, service tests, storage precautions, precautions to be used in handling them, demolitions, laboratory experiments, regulations for the transportation of explosives, and, finally, an exceedingly interesting article on "The Rôle of Chemistry in War" by Allerton S. Cushman, Ph. D., Director of the Institute of Industrial Research, Washington, D. C.

This book is freely used for reference purposes in the course in explosives at the Coast Artillery School. It is also recommended for study by *Special Regulations No. 43, Officers' Reserve Corps*, War Department, 1917.

Officers immediately in charge of the instruction of the units of the new army will find this book of great value in preparing talks on any of the many kinds of explosives which each branch will be called upon to use.

✤ ✤ ✤

Spanish for Soldiers. By Major James A. Moss and Lieut. John W. Lang, U. S. Infantry. Menasha, Wisconsin: George Banta Publishing Company. 4½" x 6". 449 pp. Cloth. 1916. Price, $1.00.

For those officers and enlisted men who already have a fairly good knowledge of Spanish, this publication is intended to furnish a handy reference book of phrases for use in campaign; while the beginner, by a study of its pages, ought to acquire a fair working knowledge for conversational purposes in military operations.

The book is logically arranged in distinct parts, giving the grammar, a basic course for noncommissioned officers, phrases, reading, a vocabulary, and an index.

While the book is small and of a convenient size, all the subjects are well covered. In fact, the indorsement by Colonel C. De W. Willcox, U. S. Army, who wrote the introduction, is sufficient in itself to establish the value of the work.

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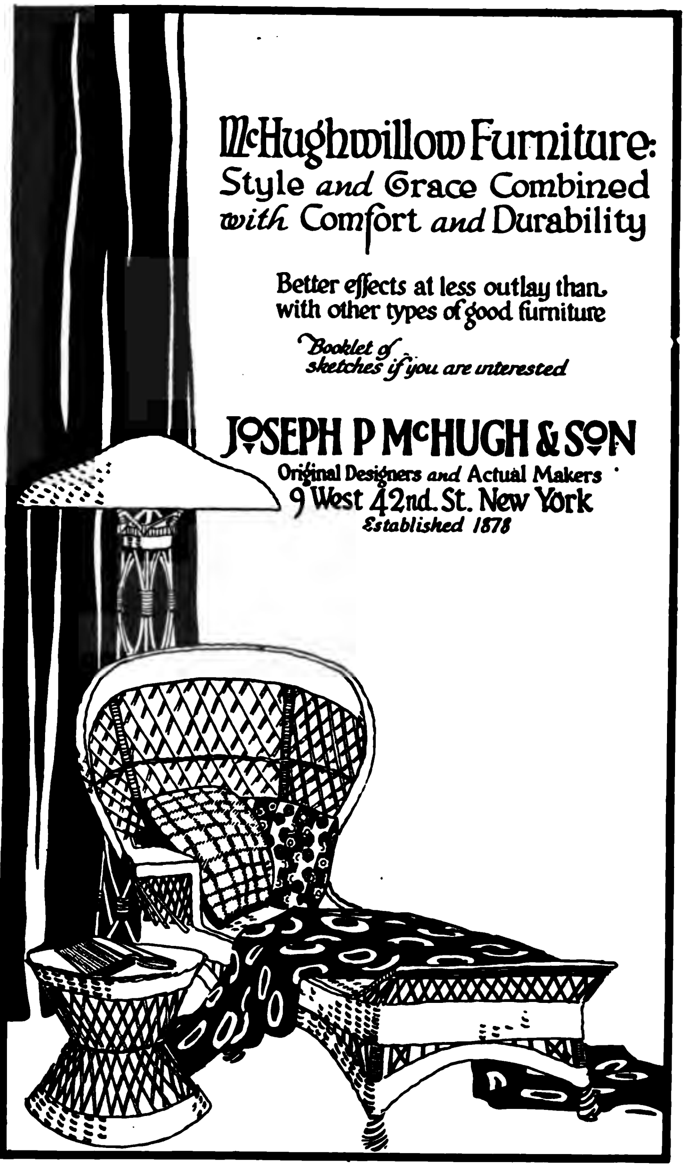

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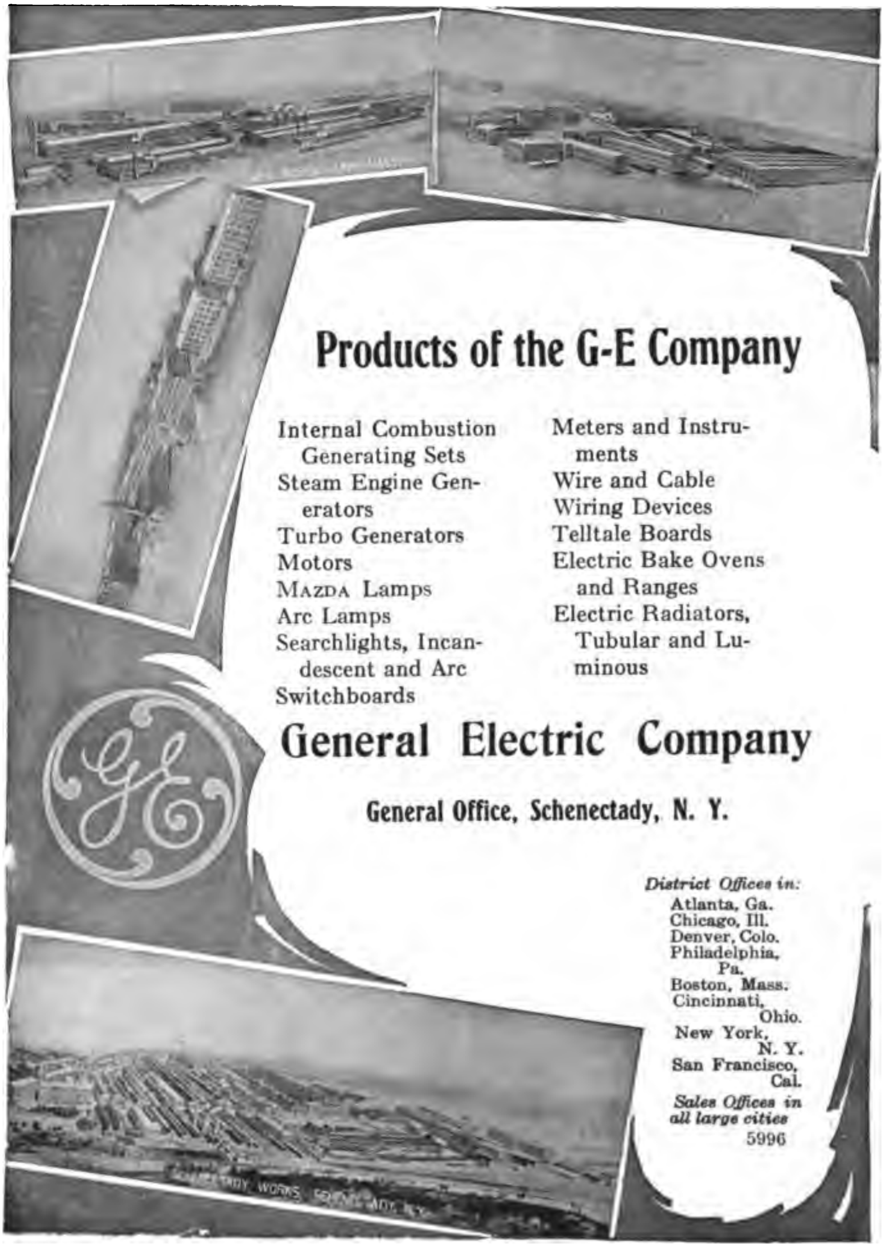

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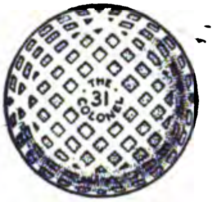

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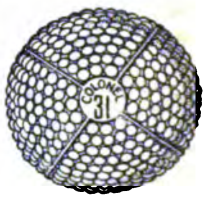

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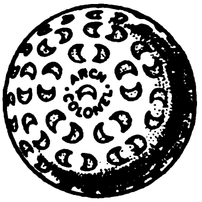
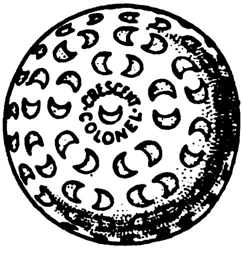
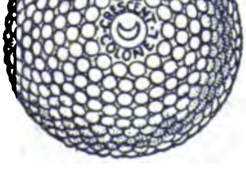


SMALL SIZE NON-FLOATER
65c EACH $7.50 DOZEN

FULL SIZE FLOATER
75c EACH $9.00 DOZEN



FULL SIZE FLOATER
65c EACH $7.50 DOZEN



FULL SIZE FLOATER

FULL SIZE NON-FLOATER

50c EACH $6.00 DOZEN

St. Mungo Mfg. Company of America

NEW YORK, 36 Warren St.
BOSTON, 143 Federal St.

NEWARK, N. J., 121-123 Sylvan Ave.
PHILADELPHIA, 1201 Chestnut St.

CHICAGO, 36 South State St.
SAN FRANCISCO, 46 Kearny S